Not to be cited without
permission of the authors[1]

Ne pas citer sans
autorisation des auteurs[1]

DFO Atlantic Fisheries
Research Document 95/29

MPO Pêches de l'Atlantique
Document de recherche 95/29

Assessment of 4X Haddock in 1994

by

P.C.F. Hurley, G.A.P. Black, R. Mohn and P. Comeau

Marine Fish Division
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia, B2Y 4A2

[1]This series documents the scientific basis for the evaluation of fisheries resources in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the secretariat.

[1]La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

Abstract

Reported landings of 4X haddock in 1994 were 4,273t, the lowest level observed in recent history. This level was a result of a decrease in the quota to 4,500t and very stringent management plans which resulted in substantial changes in the temporal and spatial patterns in the fishery in 1994. Anecdotal information suggest that catches were higher than indicated by reported landings. During industry consultations, it was indicated that discarding of undersized haddock occurred in the fixed gear sector after the closure for undersized fish and that both discarding and misreporting increased as fixed gear trip limits decreased. Mean length in the fixed gear landings increased slightly in 1994 but was still smaller than that in the mobile gear landings. Abundance in the 1994 research vessel survey increased from the historic low level in 1993; however, this increase was mainly due to the catch of large numbers of small haddock. The abundance of market size haddock in 1994 increased only slightly. The distribution of haddock in the 1994 survey indicates that abundance increased slightly in the eastern portion of the survey area but is still below average levels. Abundance increased substantially in the western portion of the survey area, due almost entirely to large catches of small haddock in the Trinity Ledge/Lurcher Shoal area. A length-based SPA was used because of evidence for bias in the ageing data in recent years. To incorporate both spatial and temporal variation in growth, separate models of mean length-at-age were used for haddock in the Bay of Fundy and on the Scotian Shelf to generate numbers-at-age. A strong retrospective pattern was again observed for this stock. Overall, the results of the analysis indicate that exploitation decreased from 1992 to 1994 but is still well above $F_{0.1}$. Spawning stock biomass is estimated to be at historically low levels. Recruitment has been below average since 1983. Given indications from the survey of one possible average (1992) and one above average year-class (1993), measures such as strict small fish protocols should be taken to allow these year-classes to mature and reproduce.

Résumé

Les débarquements déclarés d'aiglefin de 4X en 1994, soit 4,273t, étaient les plus bas de ces dernières années. Cela est dû à une réduction du quota, qui a été ramené à 4,500t, et à des plans de gestion très rigoureux, qui ont profondément modifié le régime spatio-temporel de la pêche en 1994. D'après l'information anecdotique, les prises seraient supérieures aux débarquements déclarés. Durant les consultations avec l'industrie, il a été mentionné que le rejet des aiglefins de trop petite taille était pratiqué par la flottille de pêche aux engins fixes après la fermeture de la pêche des petits aiglefins, et que les rejets et les fausses déclarations se sont accrus en même temps que les limites par sortie des bateaux de pêche aux engins fixes diminuaient. La longueur moyenne des captures de ces derniers a augmenté légèrement en 1994, mais est restée inférieure à celle de la flottille de pêche aux engins mobiles. L'abondance selon le relevé de recherche, qui avait atteint un seuil historique en 1993, a augmenté en 1994; son accroissement était toutefois essentiellement dû à la capture d'un grand nombre de petits aiglefins. L'abondance des aiglefins de taille marchande n'a augmenté que très légèrement en 1994. La distribution de l'aiglefin d'après le relevé de recherche de 1994 révèle que l'abondance a légèrement augmenté dans la partie est de la zone du relevé, mais qu'elle demeure inférieure aux moyennes. Elle s'est accrue considérablement dans la partie ouest de la zone, presque exclusivement à cause des prises importantes de petits aiglefins sur la chaussée Trinity et le haut-fond Lurcher. En raison d'une erreur systématique dans les données sur l'âge des dernières années, on a procédé à une ASP fondée sur la longueur. Pour tenir compte à la fois des variations temporelles et des variations spatiales dans la croissance, on a utilisé des modèles distincts de longueur moyenne selon l'âge pour l'aiglefin de la baie de Fundy et de la plate-forme néo-écossaise, afin d'obtenir le nombre selon l'âge. Une forte tendance rétrospective a de nouveau été observée pour ce stock. Dans l'ensemble, les résultats de l'analyse révèlent que l'exploitation a diminué de 1992 à 1994, mais qu'elle se situe encore bien au-dessus du niveau $F_{0.1}$. On estime que la biomasse du stock reproducteur a atteint des seuils historiques. Le recrutement est inférieur à la moyenne depuis 1983. Étant donné que le relevé de recherche indique la présence d'une classe annuelle (1992) qui pourrait être proche de la moyenne et d'une autre (1993) supérieure à la moyenne, il conviendrait de prendre des mesures, comme des protocoles stricts concernant le petit poisson, pour permettre à ces classes d'âge de grandir et de se reproduire.

Introduction

This document contains an evaluation of the NAFO Division 4X haddock stock (Figure 1) for the 1994 fishing year. As in the past, haddock caught in unit area 4Xs were not included in this analysis because they are believed to be part of the 5Y stock (Halliday 1974).

In a previous assessment of this stock (Frank et al. 1990), it was concluded that problems with the catch-at-age and/or the ADAPT formulation needed to be resolved before the results of Sequential Population Analysis (SPA) could be used as the basis for harvest level advice. Since that analysis, it was determined that a bias was present in haddock ages in recent years. Ageing criteria for reading haddock otoliths for this stock are presently being evaluated and age data were not available for commercial or research vessel samples collected in 1992-93. Age data determined using new ageing criteria on a subsample of otoliths from the 1994 summer research vessel survey were used in the present analysis.

Description of the Fishery

Nominal Catches

The long-term (1930-1993) reported annual landings of haddock in NAFO Division 4X have averaged about 20,000t. Landings peaked above 30,000t during the mid- to late 1960s and again during the 1980s (Figure 2). Landings declined subsequently and have been below the long-term average since 1984. Landings reached 6,700t in 1989 when it was recommended that the fishery be maintained at the lowest possible level and the mobile gear fishery was closed in mid-season. Landings increased from 1989 to 10,351t in 1992 under a Management Plan that called for a by-catch fishery only. A TAC of 6,000t was implemented in 1993 and landings that year were 6,832t. Landings in 1994 were 4,273t, the lowest level observed in recent history (Table 1). This level was a result of a decrease in the quota to 4,500t and very stringent Management Plans. Inshore mobile gear (<65ft) landings have remained low since 1989 and were 1956t in 1994 (Table 2). Fixed gear (longline and handline) landings increased from 2,699t in 1989 to 6,468t in 1992 but decreased to 2,175t in 1994. Gillnet landings in 1994 were 46t and offshore mobile gear landings were 95t.

The reduction in quota and the much more restrictive management plans resulted in substantial changes in temporal and spatial patterns in the fishery in 1994. Mobile gear landings from 4Xmnop decreased (Table 3) as the fleet continued to avoid haddock in 4X and directed for other species (flatfish, redfish, monkfish). The proportion of mobile gear landings from 4Xqr increased as some of the fleet shifted away from the banks and into deeper water.

Fixed gear landings in the first quarter decreased from 1,022t in 1993 to 331t in 1994 (Table 3, Figure 3), due to restrictive haddock trip limits in the management plan and to closures due to landings of undersized cod and haddock. Landings in the second and third quarters also

decreased due to low trip limits and closures.

The foreign catch of 4X haddock was lower than in previous years. The Small Mesh Gear box was re-defined in 1994, being more to the east and deeper than before. This change and the introduction of grates in the foreign silver hake fishery appears to have resulted in an overall reduction in groundfish by-catch in this fishery.

Allocations and management actions

Quota allocations and management actions for 4X haddock in recent years have been quite complicated, particularly during the mid- to late 1980s, and were summarized in earlier assessments (Hurley et al., 1991, 1992). Annand and Hansen (1994, 1995) summarized allocations and management actions in 1993 and 1994 respectively.

The Conservation and Harvesting Plan for the ITQ fleet for 1994 was similar to that of 1993 in terms of small fish protocols, mandatory landings, and dockside monitoring (DMP). German Bank was closed in late September due to discarding of haddock on the "Spawn Tow". Vessels fishing for flounder that aggregate to feed on herring spawn in the area, were discarding their haddock by-catch, as they did not have sufficient quota to retain the haddock. This area was re-opened in October after a test fishery, but was subsequently closed again in the end of October.

Full dockside monitoring was not required for the generalist fleet in 1994 but vessels were required to provide hails that were accurate within 10% of actual weighouts. Less than half the fleet was able to meet the established criteria and those who were unsuccessful had to comply to 100% DMP. Trip limits were established to allow the fleet to extend the quota over the year; while cod trip limits were reduced in August, no reduction was required for haddock trip limits.

The Plan for the fixed gear sector developed in 1994 was much more complex than in previous years. Haddock trip limits were not permitted once allocations were reached. The opening of the fishery was delayed until late January due to a lack of consensus in developing the Plan. The fleet sector divided into a number of quota/season/trip limit/gear groups, described in detail by Annand and Hansen (1995). Dockside monitoring was not a requirement for this fleet, although a hail system was developed for some vessels. In the spring, there were several closures due to landings of small fish. Toward the end of the season, there were transfers of quota between some groups and the entire fixed gear sector was closed in early December.

The Browns Bank spawning closure was extended to cover the period February 1-June 15.

Anecdotal information from the fishery

During consultations with the mobile gear sector, the general view was that haddock abundance in

4X has increased in the last 3-4 years but is still lower than in the early to mid-1980s. Vessels avoid areas where they know haddock catch rates have traditionally been high. They have shifted effort away from the banks and into the deeper water and direct for non-traditional species. The development of new markets has helped this situation. Reports suggest that many mobile gear vessels have changed to 140mm square mesh (likely 133mm with stretch) to avoid small haddock and to reduce catches of unwanted "trash" species. Some vessels have used mesh sizes larger than 140mm square to further minimize the by-catch of haddock. During late winter and early spring, there were reports that more haddock were being encountered in deeper water in 4Xqr than had traditionally been found. There were also a number of reports during this same period of large numbers of small haddock (8-16cm) occurring in the stomachs of cod caught in 4X.

Consultations with the fixed gear sector have not resulted in a consensus. Opinions range from haddock abundance being high to haddock abundance being at very low levels. Fishermen fishing on the banks in general reported that haddock abundance was high while some who had shifted from traditional grounds had been able to avoid haddock and maintain good catch rates for other species. Longline fishermen fishing in inshore areas in the eastern portion of 4X off Sambro and Lunenburg report that haddock have been scarce in recent years. Most longline fishermen continued to use #10 circle hooks in 1994 which are said to be more effective at catching haddock and small fish in general.

During industry consultations, it was indicated that considerable discarding of undersize haddock occurred in the fixed gear sector after the closure for undersized fish and that both discarding and misreporting (and nonreporting) of haddock increased as trip limits decreased. Some highgrading was also reported. Haddock catches are considered to have been higher that indicated by reported landings. Anecdotal information suggests that the amount of unreported catches was not more than 1,000t.

Data

Size composition of the catch

Commercial sampling data were used to construct a catch-at-length for 1994 in the same manner that would be used to construct a catch-at-age. The 1994 catch-at-length was constructed using the gear and quarter stratification shown in Table 4. The catch-at-length for the foreign catch was calculated using samples from the International Observer Program (IOP). The construction of the catch-at-length for the period 1970-93 was described by Hurley et al. (1994). The overall catch-at-length (1970-94) is shown in Table 5.

There was a change in the size composition of the commercial catch-at-length in 1994. The mean length in the catch in 1994 was 53cm compared to 51cm in 1993 and the long-term (1970-93) mean of 50cm (Figure 4). Since 1990, there has been an increase in the mean length in the mobile gear catch from 48 to 54cm in 1993. The size composition of the mobile gear catch in 1994 was

comparable to 1993, with a mean length of 54cm (Figure 5). During the same period (1990-93), there was a decrease from 54 to 49cm in the mean length in the fixed gear catch. The mean length in the fixed gear catch in 1994 increased to 51cm. During consultations, the increase in mean length in the 1994 fixed gear catch was attributed to the decrease in the extent of the winter longline fishery and to the discarding of undersized haddock that occurred after the small fish closures.

The by-catch of 4X haddock in the foreign silver hake fishery was considerably reduced in 1994 (<1000kg). An examination of the size composition from Observer samples showed modes at 24 and 30cm, corresponding to the 1993 and 1992 year-classes respectively.

Commercial catch rates

Commercial catch rates have not been considered a reliable index of haddock abundance in 4X due to the high and variable levels of misreporting, particularly in the mid-1980s, and the extent of management changes in the recent period. However, catch rates in the winter longline fishery were examined by Hurley et al. (1994) because that fishery had been relatively unrestricted. We did not examine catch rate data from this fishery in 1994 as it had been indicated during industry consultations that these data would not be comparable due to restrictive 1994 haddock trip limits.

Research vessel surveys

Results of the summer groundfish research vessel survey of the Scotian Shelf conducted in July 1970-94 were examined. The stratification scheme used in the survey is shown in Figure 6. Mean number per tow by stratum is shown in Table 6. Research vessel catch rates at length were calculated for the survey series 1970-94 (Table 7).

Research vessel catch rates were low during the 1970s and high during the early to mid-1980s (Figure 7a and 7d). Catch rates declined sharply in 1985-87 to low levels, increased in 1991 and then declined in 1993 to the lowest level observed in the series. Disaggregation of the survey data into categories less than and greater than 43cm shows the contribution of the 1987 and 1988 year-classes in 1988-90 and then a subsequent decline (Figure 7b). Catch rates of the greater than 43cm category increased abruptly in 1990-91 but then declined as abruptly in 1992-93, suggesting a year effect.

Mean number per tow of 4X haddock in the research vessel survey increased from a historical low of 12 fish per tow in 1993 to 38 fish per tow in 1994, relative to the long term mean of 45 fish per tow (Figure 7a). The substantial increase in mean numbers per tow in 1994 was due to large numbers of small fish (Figure 7b) and hence the mean weight per tow only increased from 9kg per tow in 1993 to 16kg per tow in 1994, compared to the long term mean of 37kg per tow (Figure 7d). The catch of haddock at modal lengths of 8 and 24cm (representing haddock aged 0 and 1

years old) was much larger than average (Figure 8). Such large catches may indicate strong incoming year-classes; however this needs to be confirmed by future surveys as haddock in these year-classes grow and become more available to the survey gear. The catch of haddock at a modal length of 34cm (representing haddock aged 2 years old) was below average and suggests this year-class may not be as strong as indicated in the 1993 survey (Figure 8). The 1994 survey indicates that the abundance of market size haddock (>43cm) has increased slightly, but is still only half the long term mean (Figure 7c and 7f).

The research vessel survey strata on and around Browns Bank (477, 480, 481) contribute approximately 50% on average of the survey abundance while stratum 490 in the mouth of the Bay of Fundy contributes an additional 15%. Survey strata were grouped into strata on and around Browns Bank (477, 480 and 481), strata west of Browns Bank and in the Bay of Fundy (482-495), and strata east of Browns Bank (470-476 and 478). Haddock abundance in the stratum grouping around Browns Bank showed no trend over time (Figure 9). The abundance in the stratum groupings to the east and west both show decreasing trends since the early 1990s, each reaching the lowest level in the series in 1993. The distribution of haddock in the 1994 survey indicates that haddock abundance increased in the eastern portion of the survey area (strata 470-476, 478) but was still well below average levels (Figure 9); this increase occurred predominantly on LaHave and Baccaro Banks and consisted mainly of small haddock (<43cm). The abundance of haddock in the Browns Bank area (strata 477, 480, 481) also increased in 1994 but was still below average levels (Figure 9). The abundance of haddock in the western portion of the survey area (strata 482-495) increased substantially in 1994, due almost entirely to large catches of small haddock in stratum 90 (the Trinity Ledge/Lurcher Shoal area) (Figure 9).

Estimation of Parameters and Assessment Results

There has been evidence for bias in ageing data in recent years and no routine ageing of otoliths has been conducted since 1992 pending resolution of the bias problems. Therefore, a length-based sequential population analysis (SPA) was conducted, using a modified version of the ADAPT framework (Gavaris, 1988). The method (SP-Key) initially converts numbers-at-length to numbers-at-age using cohort slicing and estimated mean lengths-at-age, and then uses SPA iteratively to modify the age template, incorporating information about cohort strengths from the SPA. The method is described in more detail by Mohn (1993).

It has been shown that there is considerable spatial variation in the growth rate of 4X haddock, with faster growth rates observed in the Bay of Fundy. In order to incorporate this spatial variation, the numbers-at-length data for both the commercial catch and the research vessel survey were subdivided into separate Bay of Fundy and Scotian Shelf components, before converting to numbers-at-age. Following the recommendations of Marshall (1995), strata 482-485 were incorporated into the Bay of Fundy stock component. Each component was assigned mean lengths-at-age, calculated from the existing aged research vessel survey data for the strata in the component. While this removed some of the variation associated with the differing growth rates,

using the aged survey data as the basis of the estimated mean lengths-at-age retains the problems due to the known ageing bias (1983-91). After conversion to numbers-at-age, the data from the two stock components were combined (within the SP-Key model) to permit the iterative SPA on a single stock entity.

It has also been shown that there is considerable temporal variation in the growth rate of 4X haddock. This is due both to the natural annual variation in growth rates, and indirectly to sampling error, including the ageing bias (1983-1991). Temporal (and spatial) variation in mean lengths-at-age are noted for young fish (ages 1-4) for which ageing biases are considered minimal. To include temporal variation in the model, mean lengths-at-age were calculated for each year of the survey series for which ageing data were available (1970-82).

No age determinations of 4X haddock were performed during 1992-1993. Mean length-at-age for these years were estimated using the averages for 1989-91. Preliminary mean length-at-age data were available for 4X haddock from the 1994 research vessel survey data, using new ageing protocols. Using these data, and the original ageing data (Table 8), four models were used for estimating the recent mean lengths-at-age.

Average - assume no change in average growth rates (set the mean lengths for each age to the mean from 1970-82) ;

Average Linear - assume movement towards the long term mean (interpolate between the 1982 values and the 1970-82 means);

Average Prorated - remove an increasing ageing bias by adjusting incrementally towards the long term mean (prorate the original age estimates with the 1970-82 means);

94 Ages Prorated - remove an increasing ageing bias by adjusting incrementally towards the interim 1994 mean lengths-at-age (prorate the original age estimates with the 1994 interim means).

The fourth model was chosen as the most appropriate balance between the historical data and the new 1994 estimates (Figure 10).

The resulting mean lengths-at-age used for 1983-94 are shown in Table 9. Haddock older than age 7 were not used in the analysis because, since the early 1970s, they have made up only a small portion of the catch (Hurley et al., 1992) and because it is not possible to easily separate modes for older ages. This results in progressively less accurate slicing at the older ages. Cohort Slicing splits age groups at the midpoint between the mean lengths-at-age. The midpoint between ages 0 and 1 was calculated as the length-at-age 1 minus the difference between length-at-age 1 and the midpoint between the length-at-ages 1 and 2. This was used to exclude age 0 haddock from the analysis. Similarly, the midpoint between ages 7 and 8 was calculated as the length-at-age 7 plus the difference between length-at-age 7 and the midpoint between the length-at-ages 6 and 7. This was used to exclude age 8+ haddock from the analysis. The catch-at-length and research vessel survey numbers-at-length data, together with the mean lengths-at-age used in the slicing are shown in Figure 11 and 12 respectively.

Examination of the historical catch-at-age since 1970 indicated that 88% of the catch occurred between ages 2 and 6. As a result, these ages were used as the index ages in the tuning. The age-based portion of the analysis was performed using the ADAPT function to fit the model as follows:

Parameters:

Terminal F estimates $F_{i,1994}$, i = 4-6
Calibration coefficients K_i, i = 2-6 for July RV survey

Structure Imposed:

Error in catch assumed negligible
Partial selection fixed for "ages" 1 and 7 in 1994
F on oldest age (7) set as average F of ages 4-6 adjusted by the relative selectivity of age 7 in 1994
No intercept was fitted
M = 0.2 for all ages

Input:

$C_{i,t}$ i = 1-7; t = 1970 to 1994 - catch-at-age for entire year
$J_{i,t}$ i = 2-6; t = 1970 to 1994 - July RV survey index

Objective function: Minimize

$$\Sigma\Sigma (\ln J_{i,t} - K_{1,i} N_{i,t})^2$$

Summary:

Number of observations = 125 for July RV (5 ages by 25 years)
Number of parameters = 8, F's estimated by NLLS, K's algebraically

The minimization technique used was a nonlinear least squares (NLLS) gradient technique (the Marquardt algorithm). The NLLS technique is a compiled version of ADAPT written in C.

Initial estimates of selectivity were obtained from the last age-based SPA (O'Boyle et al. 1989). New selectivities calculated (as per usual) from the resulting fishing mortalities in 1991-93 resulted in F patterns for 1970-88 which did not correspond well with the last age-based assessment. This may be due to changes in selectivity in 1994 compared to 1991-93. To estimate selectivity for 1994, an iterative procedure was used to adjust the selectivities interactively and create F patterns in the early years which more closely resembled those in the last age-based SPA.

age	1	2	3	4	5	6	7
initial selectivity	.001	.012	.111	.291	.690	1.00	1.00
resulting selectivity	.0001	.033	.118	.453	.884	.972	1.00

Only one iteration of SP-Key was used in these results. In some cases, further iterations produced

a marginal improvement in residual sum of squares (RSS). The resulting parameter estimates did not match those of the last age-based SPA as well, as large cohorts were overestimated at the expense of small cohorts. The results are shown in Tables 10 and 11 and Figures 13, 14 and 15.

Previous assessments of the resource have exhibited significant retrospective patterns, whereby fishing mortality in the current year is significantly underestimated and population abundance is overestimated, relative to estimates utilizing subsequent years of data. This analysis also shows a strong retrospective pattern (Figure 16).

Examination of the residual pattern in the calibration between the research vessel survey and the model shows generally negative residuals for 1970-81, and a corresponding generally positive trend since 1982 (Figure 14). The research vessel survey series consists of surveys conducted by three different vessels; the *A.T. Cameron* (1970-81), the *Lady Hammond* (1982) and the *Alfred Needler* (1983-94). Comparative fishing experiments were conducted during the transition between research vessels and a conversion factor between the *A.T. Cameron* and the *Lady Hammond/Alfred Needler* of 1.2 was calculated for haddock (Fanning 1985). The discontinuity in the residual pattern corresponds roughly with the same time period of the changeover in vessels. By repeating the SPA using alternate conversion factors, a factor of 0.55 applied to 1982-94 was found to have a minimum residual sum of squares (RSS) (28.3 vs. 38.4) and to improve the overall residual pattern in the calibration (Figure 18). The results of the analysis incorporating the new conversion factor are shown in Tables 12 and 13 and Figures 17, 18 and 19. The retrospective pattern observed using the new conversion factor was improved during the years for which the correction was applied, but was still considered strong (Figure 20). The results of this analysis indicate exploitation decreased from 1992 to 1994 but is still well above $F_{0.1}$. Population biomass (2+) is at historically low levels.

While considerable progress has been made in applying these length-based SPA techniques, there were still a number of problems identified with the analysis. The most basic shortcoming is the uncertainty concerning the ageing data. The implication of these analyses that a different conversion factor between research vessels should be used, needs to be examined in more detail. These need to be addressed before the resulting numbers of the analysis can be used; however it was felt that the overall trends are consistent with observations from the research vessel survey.

Prognosis

The survey indicates that the abundance of market size haddock is low over most of the stock area. While abundance has increased on the banks, a large part of this increase is due to small fish. Recruitment in this stock has been below average since 1983, with moderate sized 1987 and 1988 year-classes being the strongest in the recent period. The 1989, 1990 and 1991 year-classes have been weak. Population biomass is at historically low levels and exploitation is likely to be above $F_{0.1}$; however there is uncertainty at this time concerning the absolute levels.

Given indications from the survey of one possible average (1992) and one above average year-class (1993), measures such as strict small fish protocols should be taken to allow these year-classes to mature and reproduce.

Acknowledgements

The authors wish to thank the participants of the 4TVW and 4X haddock working group for their contributions, and in particular Stephen Smith for chairing the working group and Tara Marshall for her ongoing work and discussions and her assistance in generating mean length-at-age data for the revised stock components.

References

Annand, C. and J. Hansen. 1994. Management measures for 1993 and early 1994. DFO Atl. Fish. Res. Doc. 94/71: 31p.

Annand, C. and J. Hansen. 1995. Management activities for 1994 and early 1995 in the Scotia-Fundy Region. DFO Atl. Fish. Res. Doc. 95/45: 33p.

Fanning, L.P. 1985. Intercalibration of research vessel survey results obtained by different vessels. CAFSAC Res. Doc. 85/3. 43p.

Frank, K.T., P.C.F. Hurley and J. Simon. 1990. Assessment of 4X haddock in 1989. CAFSAC Res. Doc. 90/58: 48p.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29: 12p..

Halliday, R.G. 1974. Current status of the ICNAF Div. 4X haddock stock. ICNAF Res. Doc. 74/91: 24p.

Hurley, P.C.F., P. Comeau and G.A.P. Black. 1994. Assessment of 4X haddock in 1993. DFO Atl. Fish. Res. Doc. 94/39: 42p.

Hurley, P.C.F., K.T. Frank and J. Simon. 1991. Assessment of 4X haddock in 1990. CAFSAC Res. Doc. 91/67: 48p.

Hurley, P.C.F., J. Simon and K.T. Frank. 1992. Assessment of 4X haddock in 1991. CAFSAC Res. Doc. 92/63: 40p.

Marshall, C.T. 1995. Biological and geographical limits on the production dynamics of haddock (*Melanogrammus aeglefinus*) on the southwestern Scotian Shelf. Ph.D. Thesis, Dalhousie University, Halifax, N.S. 211p.

Mohn, R. 1993. A comparison of three methods to convert catch-at-length data into catch-at-age. ICCAT SCRS/93/56: 20p.

O'Boyle, R.N., K. Frank and J. Simon. 1989. An evaluation of the population dynamics of 4X haddock during 1962-88 with yield projected to 1990. CAFSAC Res. Doc. 89/58: 59p.

Table 1. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding Unit Area 4Xs) by country. The numbers in brackets represent the number of commercial samples collected in that year.

Year	Canada (MQ)	Canada (NFLD)	USA	USSR	Spain	Other	Total	TAC
1970	15560 (26)	-	1638	2	370	12	17582	18000
1971	16067 (29)	-	654	97	347	1	17166	18000
1972	12391 (36)	-	409	10	470	1	13281	9000
1973	12535 (30)	-	265	14	134	6	12954	9000
1974	12243 (25)	-	660	35	97	-	13035	-
1975	15985 (56)	-	2111	39	7	2	18144	15000
1976	16293 (45)	-	972	-	95	5	17365	15000
1977	19555 (79)	-	1648	2	-	12	21217	15000
1978	25299 (62)	114	1135	2	-	27	26577	21500
1979	24275 (49)	268	70	3	-	15	24631	26000
1980	28209 (56)	71	257	38	-	37	28612	28000
1981	30148 (82)	117	466	-	-	15	30746	27850
1982	23201 (92)	28	854	-	-	4	24087	32000
1983	24428 (119)	44	494	17	-	7	24990	32000
1984	19402 (97)	23	206	-	-	-	19631	32000
1985	14902 (86)	-	25	-	-	1	14928	15000
1986	14986 (78)	-	38	10	-	-	15034	15000
1987	13538 (82)	-	17	-	-	-	13555	15000
1988	10921 (79)	-	2	53	-	-	10976	12400
1989	6666 (43)	-	1	5	-	-	6672	4600
1990	7297 (71)	-	32	17[2]	-	3[2]	7342	4600
1991	9636 (81)	13	-	38[2]	-	3[2]	9690	-
1992	10329 (89)	5[1]	-	-	-	17[2]	10351	-
1993	6811 (86)	-	-	-	-	21[2]	6832	6000
1994	4272 (68)	-	-	-	-	1	4273	4500

Long-term Averages: 1930 - 60 = 16854 t
1961 - 83 = 25217 t
1930 - 83 = 20127 t

1 = NAFO Circular Letters
2 = I.O.P data

Table 2. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding Unit Area 4Xs) landed in the Maritimes split by tonnage class and gear type. The numbers in brackets represent the mean weight landed per age/size sample collected.

Year	Tonnage Class						Total
	TC 1-3			TC 4+			
	MB (OT)	FG (LL)[1]	Misc.[2]	MG (OT)	FG	Misc.	
1970	4894 (1224)	3281	767	6501 (296)	114	3	15560
1971	4289 (858)	3475 (1158)	499	7711 (367)	94	0	16068
1972	2742 (686)	4396 (440)	439	4750 (216)	63	0	12390
1973	1822 (304)	6090 (677)	324	4228 (282)	70	0	12534
1974	3949 (494)	6364 (530)	251	1622 (324)	55	0	12241
1975	6085 (320)	5193 (577)	271	4408 (157)	26	0	15983
1976	4347 (1087)	5305 (884)	445 (223)	6144 (186)	46	6	16293
1977	6178 (1030)	4328 (481)	550	8343 (130)	117	35	19551
1978	9413	6814 (568)	1084 (542)	7888 (164)	97	0	25296
1979	10171 (5086)	5127 (394)	600 (600)	8317 (252)	57	0	24272
1980	13043 (1186)	6911 (384)	1127 (376)	7045 (294)	82	0	28208
1981	14765 (328)	7846 (302)	993 (331)	6475 (809)	70	0	30149
1982	11670 (243)	7581 (345)	945 (79)	2972 (297)	32	0	23200
1983	12563 (224)	8533 (225)	754 (75)	2535 (195)	15	0	24400
1984	11828 (208)	6769 (226)	193 (193)	609 (76)	0	0	19399
1985	9834 (173)	4360 (182)	142	565 (113)	1	0	14902
1986	9201 (192)	5336 (184)	240	209 (209)	0	0	14986
1987	7952 (169)	4854 (270)	231 (21)	501 (84)	0	0	13538
1988	7074 (131)	3353 (152)	118 (118)	376 (188)	0	0	10921
1989	3656 (130)	2699 (245)	222	89 (22)	0	0	6666
1990	3183 (76)	3731 (133)	280 (280)	102	0	1	7297
1991	4061 (94)	5117 (151)	275 (275)	183 (61)	0	0	9636
1992	3365 (72)	6468 (175)	249 (125)	245 (82)	0	2	10329
1993	2507 (58)	4083 (136)	97 (14)	124 (31)	0	0	6811
1994	1956 (50)	2175 (84)	46	95 (48)	0	0	4272

1 = Includes handline.
2 = Gillnets (set, drift), traps, unspecified.

Table 3. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit Areas 4Xs) by gear type, tonnage class, area and quarter, 1984-94.

		OTB				LL[1]		Misc.[2]		
		mnop		qr		mnop	qr	mnop	qr	
		1-3	4+	1-3	4+	1-3	1-3	1-3	1-3	Total
1994	1	239	19	231	2	331	0	0	0	
	2	194	7	362	1	535	61	5	3	
	3	87	2	399	0	923	90	23	7	
	4	144	48	300	16	233	2	8	0	4272
1993	1	598	49	62	2	1009	13	0	0	
	2	388	49	503	4	671	220	18	5	
	3	155	3	436	11	1822	209	54	6	
	4	130	5	236	0	138	2	12	1	6811
1992	1	1006	92	76	0	1698	17	43	0	
	2	410	116	563	0	707	105	22	3	
	3	197	8	534	7	2240	256	66	51	
	4	264	8	315	14	1368	77	55	11	10329
1991	1	792	37	71	4	1800	20	10	0	
	2	305	64	766	3	451	46	27	5	
	3	200	20	627	4	1702	140	168	17	
	4	865	34	435	17	929	29	48	0	9636
1990	1	1341	42	93	1	1267	8	20	0	
	2	229	16	723	0	256	11	9	56	
	3	125	16	427	1	1447	29	115	53	
	4	128	25	117	1	707	6	27	1	7297
1989	1	2121	34	143	0	916	9	36	0	
	2	501	8	587	3	216	59	55	1	
	3	46	2	253	0	1023	36	65	1	
	4	2	42	3	0	440	0	64	0	6666
1988	1	2203	77	81	0	1368	19	25	0	
	2	1476	222	763	16	176	29	22	5	
	3	1126	17	688	4	1075	29	45	2	
	4	612	40	125	0	650	7	19	0	10921
1987	1	3026	219	108	0	2161	26	31	0	
	2	1965	163	667	5	366	58	40	1	
	3	442	42	1271	3	1201	42	85	0	
	4	89	69	384	0	995	5	74	0	13538
1986	1	2568	147	157	0	1964	5	0	0	
	2	830	20	1317	0	329	32	0	0	
	3	794	14	2284	1	1719	62	0	0	
	4	642	27	609	0	1451	13	0	0	14985
1985	1	2702	522	138	0	1926	11	12	0	
	2	2391	21	1226	0	345	46	105	29	
	3	230	17	2212	13	822	59	455	52	
	4	89	17	738	0	815	3	41	4	15041
1984	1	2280	336	188	0	2931	8	10	0	
	2	3249	334	762	0	697	34	161	17	
	3	782	85	3503	12	1350	110	462	74	
	4	164	59	815	5	1155	12	77	3	19675

1 = Includes handline.
2 = Gillnets (set, drift), traps, unspecified.

Table 4. Summary of commercial sampling for the 4X haddock fishery in 1994. Tonnes landed is followed by the number of fish measured in parentheses. The boxes represent the aggregation used in length key formation.

OTTER TRAWLS

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	239 (1317)	19 (418)	231 (1678)	2
2	194 (2090)	7	362 (891)	1
3	87 (414)	2	399 (962)	0
4	144 (472)	48	300 (895)	16

LONGLINERS/HANDLINERS

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	331 (1496)		0	
2	535 (1478)		60	
3	923 (1661)		90	
4	233 (833)		2	

MISCELLANEOUS*

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	0		0	
2	5		3	
3	23		7	
4	8		0	

* - Longline samples applied to miscellaneous landings.

Table 5. 4X haddock catch-at-length (thousands), 1970-1994.

cm.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	1	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0
16.5	4	1	14	1	3	0	0	0	0	0	0	0	0	0	0	0
18.5	19	0	24	7	3	1	4	0	0	0	0	0	0	0	0	0
20.5	48	0	31	7	6	2	8	0	0	0	9	0	0	1	0	0
22.5	19	8	11	5	6	1	7	0	0	0	2	0	0	1	2	0
24.5	15	16	4	8	3	1	5	0	0	0	13	0	0	1	0	0
26.5	22	56	2	19	4	1	3	0	0	0	1	1	0	3	0	0
28.5	20	114	0	41	11	5	29	0	1	5	22	7	8	9	8	2
30.5	18	165	1	103	99	12	34	12	8	2	52	6	22	34	32	17
32.5	103	339	39	239	211	47	106	44	29	5	29	33	58	90	108	36
34.5	308	869	138	376	696	249	130	140	38	33	86	179	139	180	227	120
36.5	569	940	356	454	564	717	354	351	173	71	212	537	251	344	375	261
38.5	729	942	531	459	471	1003	389	587	415	210	318	759	420	690	552	469
40.5	743	807	578	361	803	1074	528	907	763	410	479	821	565	1092	609	687
42.5	593	652	722	312	988	1267	569	1183	1052	577	870	1035	762	1405	951	835
44.5	576	849	756	400	865	1463	741	1396	1320	1114	1098	1317	1066	1544	1244	1082
46.5	813	737	650	492	647	1520	1064	1156	1867	1586	1406	1755	1263	1415	1355	1175
48.5	1006	692	617	490	417	1395	1268	1068	2013	1816	1423	2078	1404	1402	1406	1203
50.5	1301	725	652	587	193	1103	1280	1088	2005	1816	1577	1888	1506	1495	1327	1160
52.5	1474	792	600	526	176	769	1074	1276	1792	1859	1701	1818	1451	1394	1244	1012
54.5	1247	692	619	559	248	510	946	1284	1378	1533	1745	1628	1276	1344	1135	847
56.5	1090	705	586	550	344	417	699	1177	1091	1279	1763	1522	1217	1253	927	694
58.5	696	545	573	506	490	426	553	972	988	956	1412	1203	947	972	783	478
60.5	533	494	557	353	547	387	521	602	336	717	1076	1075	837	821	577	350
62.5	360	395	414	323	446	435	369	467	637	561	855	722	681	599	381	193
64.5	209	248	286	274	367	366	310	305	464	385	504	524	452	387	247	167
66.5	123	150	184	167	258	246	235	229	340	249	317	355	302	271	165	84
68.5	45	90	97	101	188	195	181	134	164	157	212	198	202	173	97	63
70.5	8	46	55	83	133	111	76	91	81	103	106	108	123	101	87	34
72.5	8	17	25	45	43	49	48	39	44	65	59	65	78	50	32	20
74.5	17	6	4	27	28	33	42	24	22	17	24	35	41	32	14	6
76.5	5	6	2	35	40	12	1	8	17	9	7	10	12	12	11	2
78.5	3	2	1	40	4	1	8	3	8	8	5	11	10	3	1	0
80.5	7	0	0	7	1	0	1	1	3	2	1	1	3	1	0	1
82.5	0	0	0	0	0	0	0	0	0	1	4	1	2	0	0	0
84.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86.5	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
88.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12733	12101	9135	7960	9301	13818	11583	14545	17049	15546	17368	19692	15096	17119	13897	10998

Table 5. (Continued)

cm.	1986	1987	1988	1989	1990	1991	1992	1993	1994
0.5	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0
18.5	0	0	2	2	0	0	0	0	0
20.5	0	0	4	6	0	0	0	3	0
22.5	0	0	3	4	0	0	0	8	0
24.5	0	0	1	2	0	0	0	8	0
26.5	0	0	0	4	1	0	0	3	1
28.5	1	0	0	10	1	1	0	2	0
30.5	5	0	2	17	7	2	1	3	1
32.5	40	8	6	27	41	3	4	7	3
34.5	149	40	15	23	122	7	8	13	1
36.5	301	117	31	31	131	31	21	30	5
38.5	423	274	74	53	149	91	39	58	29
40.5	584	530	144	78	195	164	128	152	53
42.5	880	768	244	110	218	256	307	255	91
44.5	1305	1016	410	232	267	400	497	365	138
46.5	1525	1204	598	376	338	525	804	409	209
48.5	1519	1368	785	558	387	609	839	563	296
50.5	1334	1352	926	623	446	635	904	550	332
52.5	1071	1139	922	517	420	642	878	566	364
54.5	866	908	863	480	434	647	759	484	348
56.5	843	612	681	421	354	553	525	351	273
58.5	366	366	470	302	301	411	384	268	199
60.5	302	233	361	203	267	336	280	202	159
62.5	158	135	195	142	223	250	186	121	106
64.5	90	73	125	77	169	175	122	79	62
66.5	63	60	71	39	102	102	67	41	42
68.5	34	21	35	15	57	62	36	21	18
70.5	21	13	19	16	25	37	17	14	7
72.5	7	3	11	4	13	14	11	7	5
74.5	9	5	9	3	3	7	7	9	2
76.5	4	0	2	1	0	2	3	2	1
78.5	0	0	0	0	1	2	1	1	0
80.5	0	0	2	0	1	0	0	0	0
82.5	1	0	0	0	0	1	0	0	0
84.5	0	0	0	0	0	0	0	0	0
86.5	0	0	0	0	0	0	0	0	0
88.5	0	0	0	0	0	0	0	0	0
90.5	0	0	0	0	0	0	0	0	0
	11901	10245	7011	4376	4673	5965	6828	4595	2744

Table 6 . 4X haddock mean numbers per standard tow by stratum in the 1970-1994 summer RV surveys.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
470	3.94	0.59	5.68	5.14	0.41	4.20	0.70	273.94	5.75	38.30	3.28	6.11
471	0.00	0.00	2.47	0.00	0.00	0.55	0.00	0.43	0.46	0.55	2.92	2.87
472	13.72	37.80	15.86	12.56	28.86	49.18	35.26	14.92	10.55	32.56	248.92	192.04
473	90.04	9.97	82.21	51.91	53.90	11.51	113.46	169.74	26.39	81.26	31.42	10.62
474	55.73	25.61	28.96	39.59	75.43	88.73	76.85	26.00	103.58	303.43	27.18	119.46
475	78.13	53.88	21.97	57.62	105.67	27.12	137.04	36.58	81.29	77.82	71.20	45.53
476	0.00	80.50	12.38	0.00	41.53	39.53	1.31	554.52	53.78	0.00	23.10	14.84
477	45.40	34.13	24.52	31.92	132.64	25.24	66.94	31.07	45.54	44.47	35.92	53.20
478	1.75	1.75	0.70	0.59	2.52	3.20	10.50	4.68	6.16	2.52	1.75	0.67
480	100.66	240.46	98.51	191.44	262.16	179.52	64.13	628.14	192.55	88.73	224.39	180.80
481	63.26	30.89	31.69	147.02	271.90	49.72	56.51	7.87	72.49	84.59	169.64	35.11
482	2.33	3.31	0.00	0.00	5.83	3.06	4.69	9.79	8.40	20.54	14.75	9.92
483	2.53	0.00	4.08	0.00	1.85	2.10	30.34	9.96	1.75	11.05	23.57	32.22
484	0.00	0.53	0.00	0.37	0.35	0.38	6.12	0.41	0.59	14.87	2.33	1.68
485	52.16	11.77	3.11	31.92	9.29	12.00	14.77	34.49	13.88	10.87	65.92	15.01
490	30.43	56.88	0.53	70.78	323.40	48.12	109.15	189.19	63.54	384.72	311.34	1481.72
491	4.15	0.00	11.39	3.91	21.08	3.01	2.58	21.30	11.52	5.21	15.37	15.48
495	16.80	13.56	9.32	4.01	20.18	1.73	4.87	33.92	48.00	31.46	6.76	8.69

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
470	0.00	35.79	12.58	0.97	41.18	6.61	6.46	4.79	1.54	0.00	0.97	0.49	0.00
471	4.89	3.89	0.46	0.00	0.51	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
472	141.20	39.75	49.03	73.40	73.09	28.21	34.73	37.78	17.47	19.11	7.89	7.32	15.00
473	135.88	34.31	60.70	189.10	174.07	80.29	12.01	12.32	41.51	92.36	5.83	0.46	46.50
474	135.37	57.81		134.50	52.61	3.15	1.54	1.80	31.11	6.32	6.69	8.26	7.80
475	47.98	53.94	254.51	100.85	159.04	14.13	13.90	22.10	54.47	22.48	16.04	8.75	128.50
476	5.50	62.34	8.75	369.87	22.39	25.03	9.10	9.21	5.30	8.51	11.67	2.83	14.75
477	94.15	86.47	150.81	92.13	120.41	43.99	59.48	42.02	24.37	38.58	39.23	12.84	56.80
478	2.94	16.77	16.73	20.42	9.48	25.39	11.32	0.00	13.82	0.00	3.25	3.40	13.50
480	73.74	93.29	172.05	117.45	97.60	52.54	84.96	175.59	251.54	360.13	200.97	71.76	144.03
481	170.30	41.82	70.77	18.68	168.47	31.93	25.72	29.26	18.03	37.65	25.32	41.43	44.13
482	23.33	8.58	20.90	1.46	2.06	31.63	22.73	18.19	39.56	20.86	1.50	7.29	19.67
483	70.04	5.66	33.42	14.58	13.00	11.48	20.59	1.54	36.84	41.78	4.03	3.83	0.00
484	6.04	1.28	4.12	2.94	0.69	0.00	1.37	0.97	0.97	0.00	0.00	0.70	0.75
485	24.85	11.29	26.44	80.44	35.57	2.97	9.68	1.86	13.13	87.06	20.51	8.40	2.00
490	485.53	234.97	773.65	160.56	31.56	44.66	128.41	129.52	174.02	79.27	104.55	18.53	414.20
491	30.48	32.01	29.26	16.34	2.75	1.03	0.26	0.00	0.67	1.30	3.56	4.80	22.33
495	37.55	14.84	3.09	5.22	0.00	0.00	0.98	0.00	18.05	0.00	0.00	0.00	5.50

Table 7. 4X haddock mean numbers-at-length per standard tow from the 1970-1994 summer RV surveys.

cm.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00
6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.11	0.01	0.13	0.15	0.12	0.06	0.00
8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.22	0.01	0.41	0.12	0.22	0.24	0.00
10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.00	0.06	0.00	0.01	0.01	0.00
12.5	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.05	0.00	0.00	0.06	0.09	0.04	0.00	0.01
14.5	0.06	0.01	0.11	0.03	0.07	0.00	0.00	0.00	0.37	0.03	1.36	2.16	1.72	0.42	0.13	0.18
16.5	0.17	0.02	0.56	0.16	0.19	0.21	0.19	0.22	1.26	0.17	2.94	7.56	4.63	2.18	1.11	1.12
18.5	0.94	0.00	1.44	1.37	1.47	1.03	1.24	0.97	2.06	0.67	4.56	6.87	4.34	2.59	1.50	2.76
20.5	2.48	0.05	2.11	2.68	5.55	2.06	2.20	1.59	1.76	0.86	7.15	8.61	5.05	0.84	1.38	2.17
22.5	1.42	0.09	0.80	2.30	3.89	1.75	1.07	1.98	0.65	0.28	4.41	7.60	4.54	1.21	2.24	2.06
24.5	0.71	0.43	0.34	1.04	0.95	1.15	0.83	1.45	0.13	0.57	1.72	5.24	5.13	1.06	4.31	1.31
26.5	0.03	2.21	0.11	2.26	0.93	0.57	0.58	0.98	0.06	1.40	0.47	2.28	4.35	0.81	3.20	1.25
28.5	0.34	3.55	0.01	4.99	3.28	0.60	1.07	2.01	0.51	2.53	0.62	3.02	3.67	1.02	3.32	3.35
30.5	0.51	3.17	0.02	7.21	8.48	0.81	1.27	2.85	0.99	2.76	1.22	4.63	3.54	1.52	4.99	2.97
32.5	1.14	1.56	0.10	3.30	7.97	0.92	1.44	5.94	1.14	2.70	1.80	4.43	3.63	2.68	6.92	4.16
34.5	1.67	0.54	0.34	2.19	5.18	0.72	1.10	7.67	1.34	3.23	2.11	5.32	2.89	3.19	6.25	5.14
36.5	0.80	0.53	0.70	0.48	5.58	1.00	1.39	8.03	1.25	1.88	3.21	4.80	2.22	2.57	4.12	4.59
38.5	0.54	0.75	0.73	0.15	6.21	0.60	0.92	9.49	1.71	1.31	3.92	4.37	2.38	1.87	4.27	5.86
40.5	0.74	1.06	0.79	0.18	7.42	1.64	0.45	9.95	2.65	1.54	3.21	2.29	2.54	1.68	4.08	6.34
42.5	0.78	1.28	0.56	0.14	5.47	2.24	0.90	10.13	3.63	1.76	3.08	2.18	1.95	1.96	4.08	6.49
44.5	0.71	1.40	0.31	0.39	2.84	1.37	1.07	10.56	1.93	2.64	3.00	2.27	1.97	1.67	3.79	6.49
46.5	1.19	1.15	0.38	0.32	1.82	1.54	1.65	6.72	1.45	2.93	2.57	2.62	1.81	1.72	2.67	5.06
48.5	1.48	1.51	0.40	0.87	0.69	2.12	1.74	6.13	1.42	3.04	2.36	2.96	2.26	1.36	2.48	2.54
50.5	1.84	1.28	0.57	0.93	0.85	1.69	2.39	4.95	1.75	2.64	3.87	1.92	2.84	2.11	1.86	2.59
52.5	1.63	2.19	0.80	1.06	0.70	0.99	2.26	2.92	1.54	1.95	3.80	1.42	1.91	1.42	1.53	1.48
54.5	1.69	1.79	0.75	0.77	1.19	0.78	1.22	4.66	1.45	1.99	4.07	1.58	2.07	1.48	1.27	1.14
56.5	1.45	2.13	0.64	0.55	0.79	0.54	1.19	3.61	1.40	1.83	3.59	1.41	1.68	1.04	1.26	1.08
58.5	0.77	1.55	0.73	0.80	1.05	0.35	0.69	2.98	1.62	1.81	2.72	1.40	1.41	0.97	1.13	0.79
60.5	0.70	1.12	0.61	0.58	0.60	0.51	0.52	1.54	0.83	1.66	1.94	0.80	0.92	0.76	0.71	0.81
62.5	0.60	0.81	0.60	0.58	0.61	0.36	0.43	1.34	0.55	1.03	1.58	1.34	0.75	0.51	0.48	0.48
64.5	0.57	0.33	0.34	0.30	0.59	0.87	0.19	0.72	0.26	0.95	1.23	0.52	0.67	0.39	0.26	0.43
66.5	0.34	0.17	0.18	0.23	0.39	0.06	0.20	0.87	0.13	0.74	0.67	0.44	0.51	0.31	0.36	0.32
68.5	0.25	0.17	0.07	0.08	0.22	0.38	0.17	0.35	0.09	0.31	0.53	0.22	0.12	0.15	0.15	0.05
70.5	0.10	0.05	0.05	0.03	0.02	0.12	0.13	0.18	0.07	0.21	0.31	0.20	0.10	0.06	0.10	0.14
72.5	0.03	0.11	0.05	0.00	0.04	0.11	0.03	0.11	0.02	0.22	0.05	0.10	0.04	0.00	0.10	0.11
74.5	0.00	0.02	0.00	0.00	0.04	0.00	0.01	0.06	0.05	0.02	0.02	0.15	0.02	0.04	0.00	0.00
76.5	0.00	0.02	0.01	0.01	0.02	0.00	0.03	0.02	0.04	0.06	0.00	0.11	0.00	0.01	0.00	0.00
78.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.02	0.03	0.00	0.03	0.01	0.00	0.00
80.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
84.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sum	25.73	31.04	15.19	35.99	75.14	27.08	28.66	111.07	34.18	46.18	74.15	91.48	72.04	40.07	70.34	73.27

Table 7. (Continued)

cm.	1986	1987	1988	1989	1990	1991	1992	1993	1994
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
6.5	0.12	0.00	0.07	0.00	0.00	0.00	0.03	0.01	0.43
8.5	0.00	0.00	0.01	0.00	0.19	0.00	0.01	0.01	1.63
10.5	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.74
12.5	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04
14.5	0.04	0.01	0.04	0.02	0.00	0.00	0.13	0.00	0.00
16.5	0.80	0.20	1.23	0.51	0.00	0.21	0.65	0.01	0.06
18.5	1.66	0.20	2.20	1.45	0.00	1.32	1.11	0.39	0.70
20.5	0.60	0.45	1.23	2.22	0.04	1.27	0.55	1.41	2.80
22.5	0.46	0.17	0.57	1.33	0.04	0.88	0.38	1.77	5.95
24.5	1.18	0.18	0.77	0.55	0.13	0.47	0.27	0.92	6.98
26.5	1.86	0.28	0.78	0.68	0.47	0.11	0.32	0.22	3.94
28.5	2.02	0.44	0.57	1.53	1.52	0.11	0.69	0.20	1.18
30.5	2.68	0.38	0.54	1.95	2.34	0.14	0.58	0.26	1.00
32.5	2.94	0.55	0.55	2.18	1.91	0.16	0.54	0.27	1.45
34.5	3.66	0.81	0.44	1.39	1.94	0.42	0.24	0.19	1.56
36.5	4.21	1.41	0.47	1.19	2.39	1.35	0.46	0.25	1.32
38.5	4.06	1.61	0.77	1.00	2.56	2.57	0.37	0.27	0.95
40.5	3.62	1.76	1.02	0.99	2.76	3.07	0.83	0.51	0.79
42.5	3.92	1.42	1.54	0.68	1.98	2.90	1.44	0.46	0.54
44.5	3.85	1.80	2.05	0.70	1.51	2.94	2.08	0.52	0.71
46.5	3.27	1.63	1.49	0.89	1.21	4.44	1.94	0.63	0.79
48.5	2.91	1.37	1.28	1.20	0.98	3.59	1.51	0.48	0.80
50.5	2.56	1.34	1.36	0.80	1.46	2.99	1.36	0.77	0.92
52.5	1.37	1.29	0.87	0.86	1.06	2.56	1.52	0.44	0.72
54.5	1.58	1.00	0.94	0.59	1.14	2.72	1.24	0.38	0.50
56.5	0.75	0.72	0.56	0.44	0.94	1.75	1.34	0.59	0.34
58.5	0.79	0.48	0.37	0.38	0.67	1.20	0.67	0.35	0.17
60.5	0.38	0.21	0.40	0.18	0.45	0.79	0.49	0.23	0.27
62.5	0.11	0.13	0.21	0.17	0.66	0.57	0.50	0.12	0.11
64.5	0.12	0.06	0.18	0.04	0.42	0.24	0.36	0.11	0.18
66.5	0.23	0.06	0.15	0.03	0.38	0.24	0.13	0.10	0.16
68.5	0.07	0.02	0.13	0.02	0.11	0.16	0.16	0.03	0.09
70.5	0.05	0.00	0.06	0.01	0.09	0.10	0.02	0.00	0.08
72.5	0.06	0.00	0.03	0.00	0.03	0.07	0.01	0.00	0.08
74.5	0.04	0.00	0.05	0.00	0.02	0.00	0.00	0.00	0.00
76.5	0.00	0.00	0.02	0.00	0.04	0.01	0.00	0.00	0.00
78.5	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
80.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sum	51.93	20.03	22.95	23.96	29.46	39.35	21.93	11.93	36.02

Table 8. Mean length-at-age (cm) from the summer RV survey, 1970 - 1991, for Scotian Shelf and Bay of Fundy components.

Scotian Shelf

Year	Age						
	1	2	3	4	5	6	7
1970	20.6	32.5	41.6	45.0	49.3	51.8	54.7
1971	20.2	30.0	40.5	46.5	51.2	53.7	55.5
1972	20.2	29.5	39.4	47.2	52.4	55.6	57.3
1973	20.5	30.5	39.0	47.2	53.3	57.3	59.6
1974	20.8	31.0	39.6	46.8	54.0	57.9	61.2
1975	21.0	31.5	40.5	47.5	54.0	57.8	62.3
1976	20.8	32.0	41.0	48.2	53.7	57.3	62.8
1977	20.2	32.0	41.2	48.4	53.8	57.1	62.8
1978	19.4	30.5	40.0	48.2	53.3	57.5	62.1
1979	18.8	29.0	38.8	47.8	53.2	58.0	61.6
1980	18.2	29.0	38.8	47.4	53.6	57.8	61.2
1981	17.4	28.0	39.0	46.6	53.0	57.2	60.6
1982	17.2	26.0	37.2	45.5	51.7	56.8	59.9
1983	17.3	24.5	35.0	43.6	51.1	56.1	59.1
1984	17.7	24.5	34.0	41.8	50.0	55.7	58.1
1985	18.2	25.5	33.6	41.6	49.2	56.0	58.5
1986	18.8	28.0	34.0	41.6	49.5	56.0	59.1
1987	19.0	28.5	34.5	42.5	50.1	55.9	59.3
1988	19.4	29.5	35.8	43.6	50.7	56.1	59.8
1989	20.0	29.5	36.5	45.6	51.8	57.3	60.6
1990	21.0	30.0	39.0	47.2	53.1	59.5	61.9
1991	21.0	30.0	38.5	47.4	54.0	60.9	64.2

Bay of Fundy

Year	Age						
	1	2	3	4	5	6	7
1970	21.0	34.5	42.2	47.8	50.7	52.5	56.8
1971	20.8	33.6	43.0	49.0	51.2	54.9	57.6
1972	21.0	33.0	43.2	50.5	54.6	57.8	59.4
1973	21.4	32.8	43.4	50.5	56.2	60.1	61.1
1974	22.0	33.6	44.0	50.0	57.0	61.8	62.3
1975	22.4	34.4	44.5	50.2	57.0	61.9	63.1
1976	22.6	35.2	45.5	51.0	57.1	62.0	64.6
1977	22.6	36.2	46.5	52.0	57.2	61.9	64.8
1978	22.4	36.2	46.0	52.4	57.6	61.7	64.5
1979	21.8	36.0	45.5	52.0	58.1	62.0	64.9
1980	21.6	35.2	45.0	51.8	58.5	62.5	65.2
1981	21.6	34.6	44.6	51.4	58.3	62.6	65.5
1982	21.6	34.0	44.2	50.6	57.3	61.9	65.0
1983	21.8	33.8	43.6	50.0	56.5	60.8	64.0
1984	22.0	33.8	43.0	49.2	55.7	60.1	63.1
1985	22.4	33.8	42.6	48.8	55.6	60.5	63.7
1986	22.5	33.2	42.4	49.2	56.0	61.1	64.9
1987	22.5	33.0	42.2	50.0	56.3	61.4	66.1
1988	22.5	33.4	43.0	51.0	57.1	62.4	67.8
1989	22.6	34.0	44.0	52.0	58.1	63.8	69.0
1990	23.0	34.4	45.5	53.2	59.9	64.9	70.1
1991	23.5	34.2	45.2	53.8	60.4	65.5	71.3

Table 9. Mean length-at-age (cm) for 1983-94 calculated from 94 pro-rated model (see text for explanation) for Scotian Shelf and Bay of Fundy components.

Scotian Shelf

Year	Age						
	1	2	3	4	5	6	7
1983	17.8	25.2	35.4	43.7	51.2	55.9	58.7
1984	18.5	26.0	35.0	42.3	50.3	55.4	57.5
1985	19.3	27.5	35.1	42.4	49.9	55.4	57.4
1986	20.1	29.8	35.9	42.7	50.3	55.2	57.5
1987	20.5	30.5	36.7	43.5	50.9	54.9	57.2
1988	21.0	31.4	37.8	44.2	51.4	54.9	57.0
1989	21.6	31.8	39.3	45.2	51.9	55.1	56.9
1990	22.1	32.3	39.5	45.7	52.4	55.6	56.8
1991	22.3	32.5	39.5	45.5	52.5	55.4	56.7
1992	22.4	32.8	39.6	45.2	52.5	54.5	55.5
1993	22.5	33.1	39.7	45.1	52.1	54.1	54.9
1994	22.7	33.4	39.8	44.9	52.0	53.6	54.2

Bay of Fundy

Year	Age						
	1	2	3	4	5	6	7
1983	22.0	34.0	43.9	50.3	57.0	61.1	64.3
1984	22.4	34.2	43.6	49.9	56.8	60.9	63.9
1985	22.9	34.4	43.6	50.0	57.2	61.5	64.7
1986	23.1	34.2	43.9	50.7	58.1	62.3	65.8
1987	23.3	34.3	44.1	51.5	58.8	62.8	66.7
1988	23.4	34.8	44.9	52.3	59.6	63.5	67.7
1989	23.6	35.2	45.6	52.9	60.5	64.3	68.2
1990	23.9	35.5	46.4	53.5	61.4	64.8	68.4
1991	24.2	35.6	46.4	53.6	61.8	64.9	68.5
1992	24.2	35.8	46.5	53.5	61.7	64.7	68.0
1993	24.3	35.9	46.6	53.6	62.0	64.7	67.8
1994	24.4	36.1	46.8	53.6	62.2	64.7	67.6

Table 10. SPA input data generated by cohort slicing and SP Key using mean lengths-at-age calculated from 94 ages prorated model.

A.

Catch Numbers-at-Age

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
1	75	2	57	15	13	3	19	0	0	0	9	0	0
2	431	1283	148	1112	677	376	604	563	156	113	196	350	162
3	1394	2058	1751	782	3848	2908	1292	3359	2858	1110	2298	2312	1838
4	1680	2965	1859	2087	1110	7158	3808	3434	6821	6322	4240	7671	3966
5	2367	1605	2228	1235	1262	986	4301	3760	3439	4903	6216	4035	4975
6	2283	1311	824	1202	586	1038	491	2672	2106	1450	2513	2789	1470
7	2583	1023	728	447	740	370	487	240	1096	787	771	880	1027
1-7	10812	10248	7595	6880	8236	12839	11002	14028	16477	14684	16244	18038	13437

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
1	0	0	0	0	0	6	8	0	0	0	13	0
2	111	172	72	100	43	38	106	185	24	31	59	56
3	2558	1146	1383	1006	960	327	377	851	610	345	512	189
4	5808	5492	3483	5282	3706	2155	1143	1290	2400	2942	1269	777
5	3978	3861	4154	3211	3691	2112	1421	781	1273	1895	1414	370
6	2455	1165	918	1248	955	1224	576	546	461	533	547	540
7	772	674	285	264	388	426	356	286	369	218	254	258
1-7	15683	12510	10295	11110	9743	6289	3987	3939	5138	5963	4068	2190

B.

RV Mean Numbers-at-Age per Tow

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
1	5.65	0.69	5.37	7.63	11.89	6.50	5.88	6.43	6.25	2.60	21.36	34.89	19.72
2	3.77	11.08	0.75	20.07	27.79	3.80	6.86	33.70	4.85	14.04	8.55	25.28	23.13
3	3.48	3.67	2.85	1.15	27.19	6.28	3.72	39.73	9.71	7.32	16.38	12.47	11.50
4	1.95	4.52	1.35	2.40	2.19	6.80	5.38	12.89	5.83	10.54	8.96	9.44	6.52
5	2.35	2.47	1.74	1.51	2.44	0.85	4.37	9.36	2.34	5.80	10.59	3.23	6.09
6	2.37	2.43	0.77	1.65	1.02	1.00	0.45	6.76	1.78	2.38	4.52	2.73	2.20
7	2.85	1.97	0.69	0.63	1.19	0.37	0.43	0.62	0.98	1.64	1.44	1.04	1.85
1-7	22.42	26.85	13.53	35.05	73.71	25.59	27.08	109.51	31.74	44.33	71.80	89.07	71.01

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
1	7.64	7.54	9.02	4.86	1.37	6.62	6.73	0.66	4.25	3.41	4.90	20.04
2	7.08	24.27	13.80	12.39	2.54	2.91	8.55	10.48	2.42	2.65	1.13	8.27
3	11.56	15.77	26.10	13.54	5.96	3.64	3.58	9.36	12.78	3.26	1.87	1.98
4	6.05	13.72	13.81	13.81	5.13	5.11	2.26	3.70	12.41	6.87	1.39	2.12
5	3.34	4.47	7.04	4.32	3.31	2.17	1.64	1.82	3.97	3.38	1.38	0.65
6	2.22	1.52	1.86	1.81	0.95	1.37	0.70	1.73	1.56	1.26	0.61	1.02
7	0.73	1.00	0.76	0.45	0.43	0.67	0.47	1.18	1.44	0.65	0.31	0.56
1-7	38.62	68.29	72.38	51.19	19.69	22.48	23.92	28.93	38.82	21.47	11.59	34.64

Table 11. SPA results using input data generated using mean lengths-at-age calculated from 94 ages prorated model.

A. Fishing Mortality

	Year												
Age	70	71	72	73	74	75	76	77	78	79	80	81	82
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.10	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.00	0.01	0.02	0.01
3	0.10	0.26	0.19	0.15	0.15	0.15	0.08	0.13	0.10	0.07	0.09	0.15	0.11
4	0.29	0.32	0.41	0.35	0.34	0.44	0.31	0.33	0.44	0.35	0.38	0.51	0.43
5	0.46	0.49	0.43	0.52	0.37	0.57	0.53	0.58	0.65	0.66	0.71	0.78	0.76
6	0.59	0.51	0.51	0.44	0.51	0.60	0.63	0.75	0.76	0.64	0.89	0.83	0.76
7	0.58	0.57	0.58	0.57	0.51	0.70	0.61	0.72	0.80	0.72	0.86	0.92	0.84
3-6	0.36	0.40	0.38	0.37	0.34	0.44	0.39	0.45	0.49	0.43	0.52	0.57	0.51

	Year											
Age	83	84	85	86	87	88	89	90	91	92	93	94
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
3	0.14	0.09	0.08	0.09	0.12	0.07	0.06	0.10	0.06	0.09	0.13	0.05
4	0.62	0.52	0.42	0.53	0.59	0.45	0.39	0.33	0.43	0.49	0.58	0.30
5	1.08	1.18	0.99	0.90	0.89	0.82	0.61	0.52	0.64	0.72	0.46	0.33
6	1.15	1.18	1.06	0.98	0.76	0.87	0.55	0.50	0.67	0.61	0.46	0.31
7	1.23	1.24	1.07	1.04	0.97	0.93	0.67	0.58	0.75	0.78	0.65	0.41
3-6	0.75	0.74	0.64	0.62	0.59	0.55	0.41	0.36	0.45	0.48	0.41	0.25

B. Population Numbers

	Year											
Age	70	71	72	73	74	75	76	77	78	79	80	81	82
1	18887	9323	48111	34529	27218	44980	48409	28834	42398	26910	28934	31713	22360
2	12425	15396	7631	39338	28256	22272	36824	39616	23608	34712	22032	23681	25964
3	16035	9783	11444	6113	31201	22521	17895	29602	31925	19187	28318	17861	19071
4	7434	11867	6148	7785	4298	22064	15808	13482	21197	23552	14704	21106	12531
5	7072	4566	7032	3351	4486	2515	11587	9496	7931	11182	13563	8202	10338
6	3657	3648	2286	3742	1627	2531	1167	5595	4373	3382	4719	5480	3064
7	6411	2567	1801	1126	1975	801	1133	511	2163	1675	1457	1589	1962
1-7	73921	57149	84452	95985	99061	117684	132822	127138	133595	120600	113726	109631	95292

	Year											
Age	83	84	85	86	87	88	89	90	91	92	93	94
1	28539	18488	13725	7655	9930	15499	16635	6403	6916	6723	5753	0
2	18307	23366	15136	11237	6267	8130	12684	13612	5243	5662	5505	4698
3	21112	14888	18974	12327	9110	5092	6621	10288	10978	4270	4608	4453
4	13952	14970	11152	14284	9182	6590	3874	5080	7654	8436	3184	3309
5	6671	6167	7287	5979	6916	4164	3445	2137	2992	4065	4245	1459
6	3963	1862	1556	2207	1990	2322	1499	1535	1043	1298	1638	2196
7	1178	1023	470	443	678	765	793	706	763	436	580	846
1-7	93721	80764	68301	54133	44073	42563	45552	39763	35588	30921	25512	16962

C. Residuals

	Year												
Age	70	71	72	73	74	75	76	77	78	79	80	81	82
2	-0.47	0.42	-1.61	0.04	0.70	-1.06	-0.97	0.54	-0.88	-0.21	-0.24	0.77	0.59
3	-0.93	-0.28	-0.74	-1.03	0.49	-0.64	-0.98	0.92	-0.59	-0.38	0.05	0.27	0.10
4	-0.80	-0.40	-0.90	-0.60	-0.11	-0.55	-0.53	0.52	-0.66	-0.23	0.10	-0.13	-0.03
5	-0.59	-0.09	-0.91	-0.25	-0.15	-0.52	-0.43	0.56	-0.60	-0.03	0.40	-0.24	0.15
6	-0.46	-0.05	-0.72	-0.50	-0.11	-0.51	-0.54	0.69	-0.40	0.08	0.54	-0.15	0.17
4-6	-0.73	-0.09	-1.08	-0.53	0.36	-0.75	-0.83	0.66	-0.71	-0.27	-0.03	0.30	0.22

	Year											
Age	83	84	85	86	87	88	89	90	91	92	93	94
2	-0.25	0.74	0.61	0.80	-0.20	-0.33	0.31	0.44	-0.07	-0.06	-0.88	1.27
3	0.03	0.65	0.91	0.69	0.19	0.25	-0.03	0.50	0.73	0.33	-0.28	-0.24
4	-0.10	0.59	0.83	0.64	0.13	0.38	0.06	0.25	1.10	0.45	-0.12	0.10
5	0.18	0.60	0.78	0.44	0.02	0.07	-0.15	0.38	0.89	0.46	-0.61	-0.38
6	0.16	0.55	0.85	0.44	-0.23	0.05	-0.38	0.47	0.85	0.39	-0.66	-0.52
4-6	-0.11	0.66	0.78	0.71	0.04	0.10	0.11	0.40	0.59	0.24	-0.43	0.38

Table 12. SPA input data generated by cohort slicing and SP Key using mean lengths-at-age calculated from 94 ages prorated model, incorporating 0.55 factor for 82-94 RV survey data.

A.
Catch Numbers-at-Ages

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
1	75	2	57	15	13	3	19	0	0	0	9	0	0
2	432	1281	148	1113	678	377	605	564	143	102	184	320	149
3	1399	2065	1751	783	3852	2915	1296	3368	2879	1034	2161	2189	1727
4	1684	2969	1864	2085	1108	7155	3814	3436	6831	6412	4151	7490	3851
5	2364	1602	2225	1236	1257	983	4292	3753	3430	4904	6419	4067	4950
6	2279	1308	823	1202	587	1035	490	2667	2101	1447	2544	3031	1558
7	2580	1021	727	447	741	371	486	240	1093	785	777	941	1202
1-7	**10812**	**10248**	**7595**	**6880**	**8236**	**12839**	**11002**	**14028**	**16477**	**14684**	**16244**	**18038**	**13437**

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
1	0	0	0	0	0	6	9	0	0	0	13	0
2	110	174	73	101	43	39	108	193	23	30	58	57
3	2396	1144	1396	1022	972	333	385	865	647	342	518	199
4	5709	5283	3473	5301	3739	2190	1164	1304	2432	3060	1337	830
5	3957	3861	4044	3185	3681	2116	1429	783	1260	1865	1427	378
6	2605	1248	974	1215	934	1193	555	527	435	476	488	495
7	906	799	335	287	373	412	337	268	342	191	227	230
1-7	**15683**	**12510**	**10295**	**11110**	**9743**	**6289**	**3987**	**3939**	**5138**	**5963**	**4068**	**2190**

B.
RV Mean Numbers-at-Age per Tow

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
1	5.65	0.69	5.37	7.63	11.89	6.50	5.88	6.36	6.24	2.55	21.27	34.58	10.85
2	3.77	11.07	0.75	20.07	27.79	3.80	6.86	33.78	4.68	13.85	8.32	25.10	12.55
3	3.48	3.67	2.84	1.15	27.18	6.28	3.72	39.73	9.88	7.21	16.17	12.52	6.28
4	1.95	4.53	1.36	2.40	2.19	6.80	5.38	12.89	5.84	10.86	8.91	9.53	3.56
5	2.35	2.47	1.74	1.52	2.44	0.85	4.37	9.36	2.34	5.84	11.05	3.29	3.37
6	2.37	2.43	0.78	1.65	1.03	1.00	0.45	6.76	1.78	2.38	4.62	2.95	1.27
7	2.85	1.97	0.69	0.63	1.19	0.37	0.43	0.62	0.98	1.64	1.46	1.10	1.17
1-7	**22.42**	**26.85**	**13.53**	**35.05**	**73.71**	**25.59**	**27.08**	**109.51**	**31.74**	**44.33**	**71.80**	**89.07**	**39.06**

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
1	4.20	4.16	4.96	2.67	0.75	3.65	3.72	0.35	2.33	1.87	2.69	11.01
2	3.89	13.36	7.62	6.82	1.40	1.60	4.70	5.88	1.29	1.44	0.62	4.56
3	6.19	8.65	14.37	7.49	3.29	2.01	1.97	5.11	7.28	1.78	1.04	1.12
4	3.33	7.37	7.55	7.58	2.83	2.82	1.25	2.02	6.76	3.91	0.80	1.21
5	1.85	2.49	3.78	2.36	1.82	1.19	0.90	1.00	2.14	1.84	0.77	0.36
6	1.30	0.89	1.06	0.97	0.51	0.74	0.37	0.93	0.81	0.63	0.30	0.51
7	0.47	0.64	0.47	0.27	0.23	0.36	0.25	0.62	0.74	0.33	0.15	0.28
1-7	**21.24**	**37.56**	**39.81**	**28.15**	**10.83**	**12.36**	**13.16**	**15.91**	**21.35**	**11.81**	**6.37**	**19.05**

Table 13. SPA results using input data generated using mean lengths-at-age calculated from 94 ages prorated model, incorporating 0.55 factor for 82-94 RV survey data.

A. Fishing Mortality

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.10	0.02	0.03	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.02	0.01
3	0.10	0.26	0.19	0.15	0.15	0.15	0.08	0.13	0.10	0.06	0.09	0.15	0.11
4	0.29	0.32	0.41	0.35	0.34	0.44	0.31	0.33	0.43	0.33	0.36	0.49	0.41
5	0.46	0.49	0.43	0.52	0.37	0.57	0.53	0.57	0.64	0.64	0.65	0.72	0.70
6	0.59	0.51	0.51	0.44	0.51	0.60	0.62	0.74	0.74	0.61	0.83	0.76	0.69
7	0.58	0.57	0.58	0.57	0.53	0.70	0.63	0.71	0.78	0.69	0.80	0.85	0.78
3-6	**0.36**	**0.40**	**0.38**	**0.37**	**0.34**	**0.44**	**0.38**	**0.44**	**0.48**	**0.41**	**0.48**	**0.53**	**0.48**

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02
3	0.14	0.09	0.09	0.10	0.13	0.08	0.07	0.11	0.08	0.11	0.17	0.08
4	0.60	0.52	0.43	0.54	0.61	0.48	0.43	0.37	0.49	0.64	0.82	0.46
5	1.01	1.13	1.00	0.92	0.93	0.88	0.67	0.59	0.75	0.90	0.71	0.57
6	1.07	1.12	1.05	1.00	0.78	0.93	0.60	0.56	0.78	0.72	0.63	0.57
7	1.16	1.20	1.08	1.07	1.01	0.99	0.74	0.66	0.88	0.98	0.93	0.69
3-6	**0.70**	**0.71**	**0.64**	**0.64**	**0.61**	**0.59**	**0.44**	**0.41**	**0.52**	**0.59**	**0.58**	**0.42**

B. Population Numbers

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
1	18866	9320	48172	34691	27480	45762	51370	29688	42895	26921	28782	30508	22032
2	12463	15379	7628	39389	28389	22487	37464	42040	24307	35119	22041	23557	24978
3	16055	9813	11432	6111	31241	22629	18069	30126	33909	19771	28661	17880	18997
4	7432	11879	6166	7776	4295	22093	15889	13621	21618	25157	15252	21511	12658
5	7063	4562	7039	3361	4480	2514	11614	9558	8043	11518	14795	8731	10835
6	5648	3643	2286	3750	1634	2530	1169	5625	4430	3482	4993	6305	3469
7	6399	2562	1799	1127	1982	806	1135	514	2192	1726	1541	1786	2420
1-7	**73927**	**57158**	**84522**	**96204**	**99501**	**118821**	**136711**	**131173**	**137393**	**123695**	**116066**	**110277**	**95387**

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
1	28185	18199	13365	7288	9188	14202	14403	5411	5397	4263	3425	0
2	18038	23076	14900	10942	5967	7523	11622	11784	4430	4418	3491	2792
3	20315	14668	18736	12133	8868	4846	6124	9418	9474	3606	3591	2805
4	13991	14465	10974	14077	9009	6380	3667	4665	6928	7171	2643	2471
5	6879	6289	7062	5842	6729	3993	3243	1948	2640	3472	3103	954
6	4392	2052	1655	2123	1901	2178	1354	1362	887	1022	1155	1249
7	1430	1239	551	474	638	711	704	607	638	333	406	504
1-7	**93230**	**79988**	**67243**	**52878**	**42300**	**39834**	**41116**	**35195**	**30393**	**24285**	**17813**	**10776**

C. Residuals

	Year												
Age	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*
2	-0.23	0.67	-1.36	0.29	0.94	-0.82	-0.74	0.73	-0.70	0.01	-0.03	1.02	0.26
3	-0.67	-0.03	-0.48	-0.78	0.75	-0.39	-0.73	1.16	-0.37	-0.17	0.28	0.53	-0.24
4	-0.54	-0.15	-0.65	-0.34	0.15	-0.29	-0.27	0.77	-0.43	-0.02	0.30	0.10	-0.40
5	-0.34	0.17	-0.65	0.00	0.10	-0.26	-0.18	0.80	-0.37	0.18	0.58	-0.06	-0.27
6	-0.20	0.22	-0.46	-0.24	0.16	-0.25	-0.28	0.94	-0.15	0.30	0.73	0.01	-0.28
4-6	**-0.48**	**0.17**	**-0.83**	**-0.28**	**0.61**	**-0.50**	**-0.58**	**0.88**	**-0.50**	**-0.06**	**0.19**	**0.55**	**-0.13**

	Year											
Age	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	*93*	*94*
2	-0.59	0.40	0.28	0.48	-0.50	-0.60	0.04	0.26	-0.29	-0.17	-0.78	1.45
3	-0.31	0.33	0.59	0.38	-0.11	-0.03	-0.29	0.25	0.58	0.16	-0.34	-0.07
4	-0.46	0.26	0.51	0.32	-0.17	0.09	-0.20	0.01	0.89	0.40	-0.08	0.19
5	-0.23	0.23	0.45	0.12	-0.28	-0.21	-0.40	0.17	0.72	0.38	-0.49	-0.16
6	-0.27	0.14	0.49	0.13	-0.52	-0.21	-0.62	0.27	0.69	0.27	-0.65	-0.23
4-6	**-0.45**	**0.33**	**0.46**	**0.39**	**-0.26**	**-0.18**	**-0.15**	**0.17**	**0.40**	**0.13**	**-0.40**	**0.52**

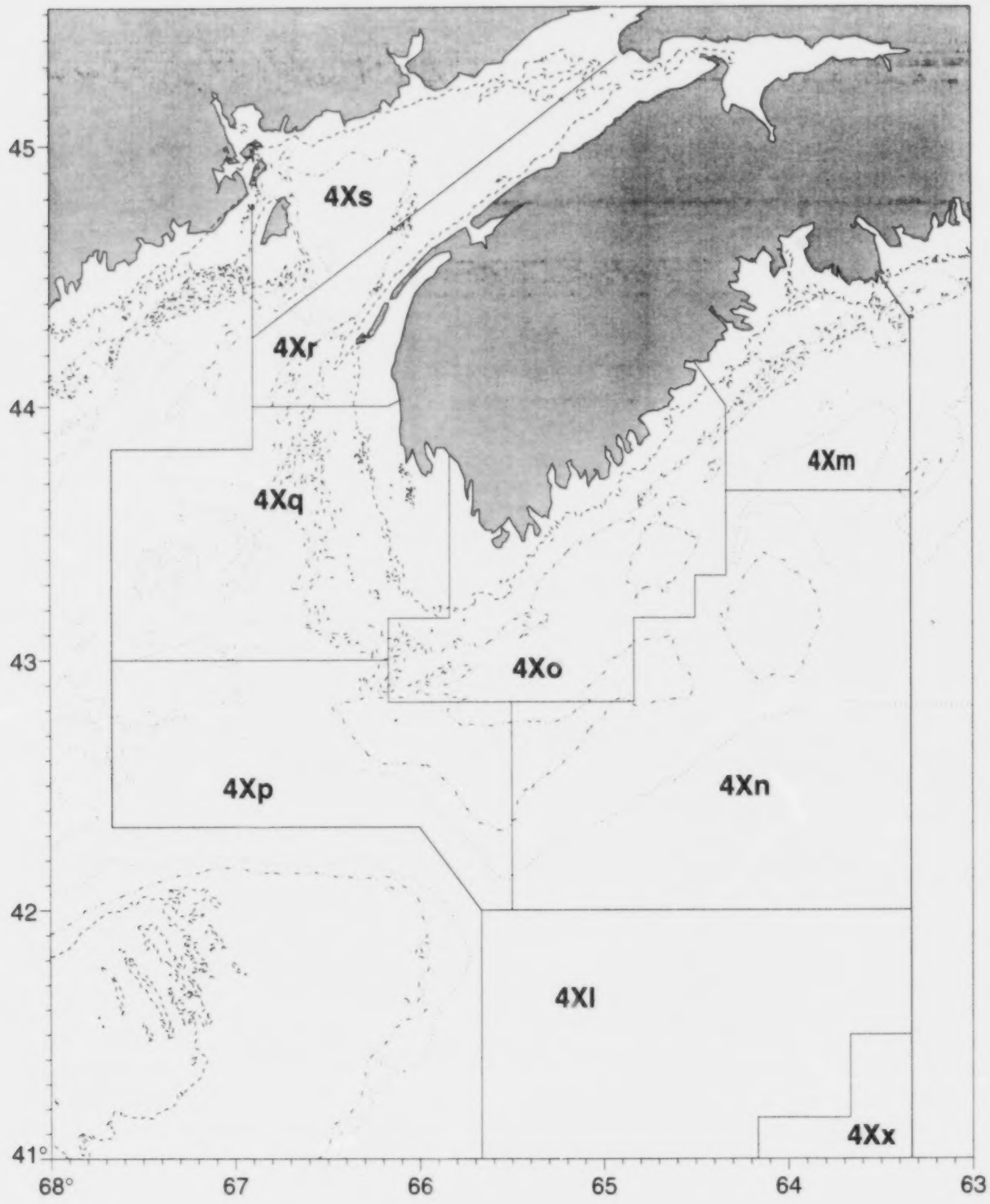


Figure 1. Unit areas in NAFO Division 4X.

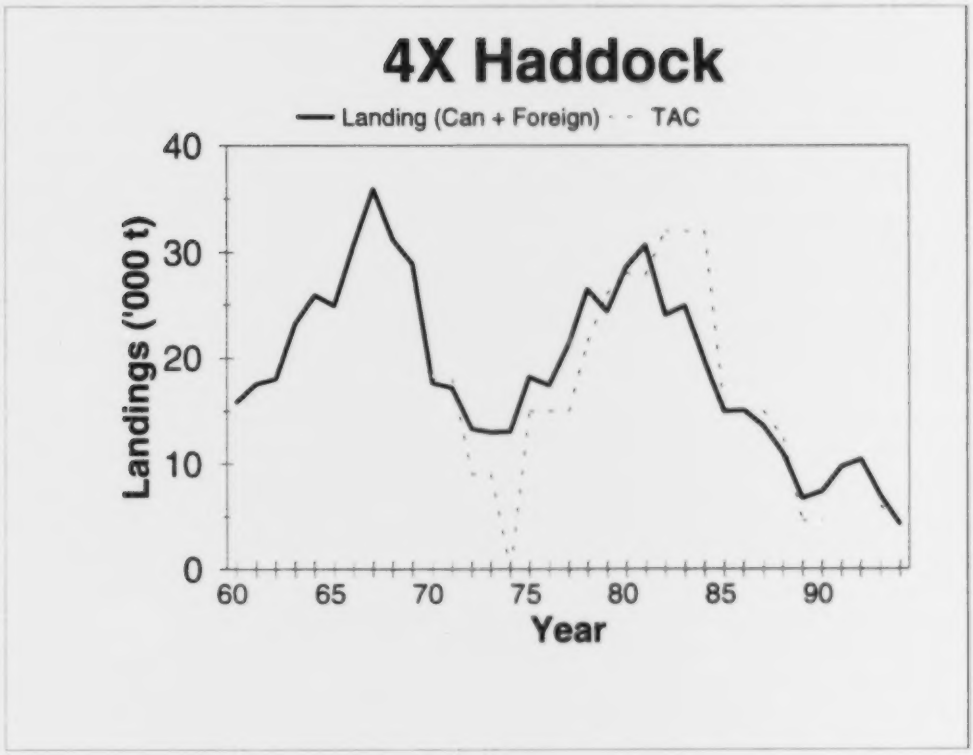


Figure 2. Long-term trends in 4X haddock landings, along with TAC.

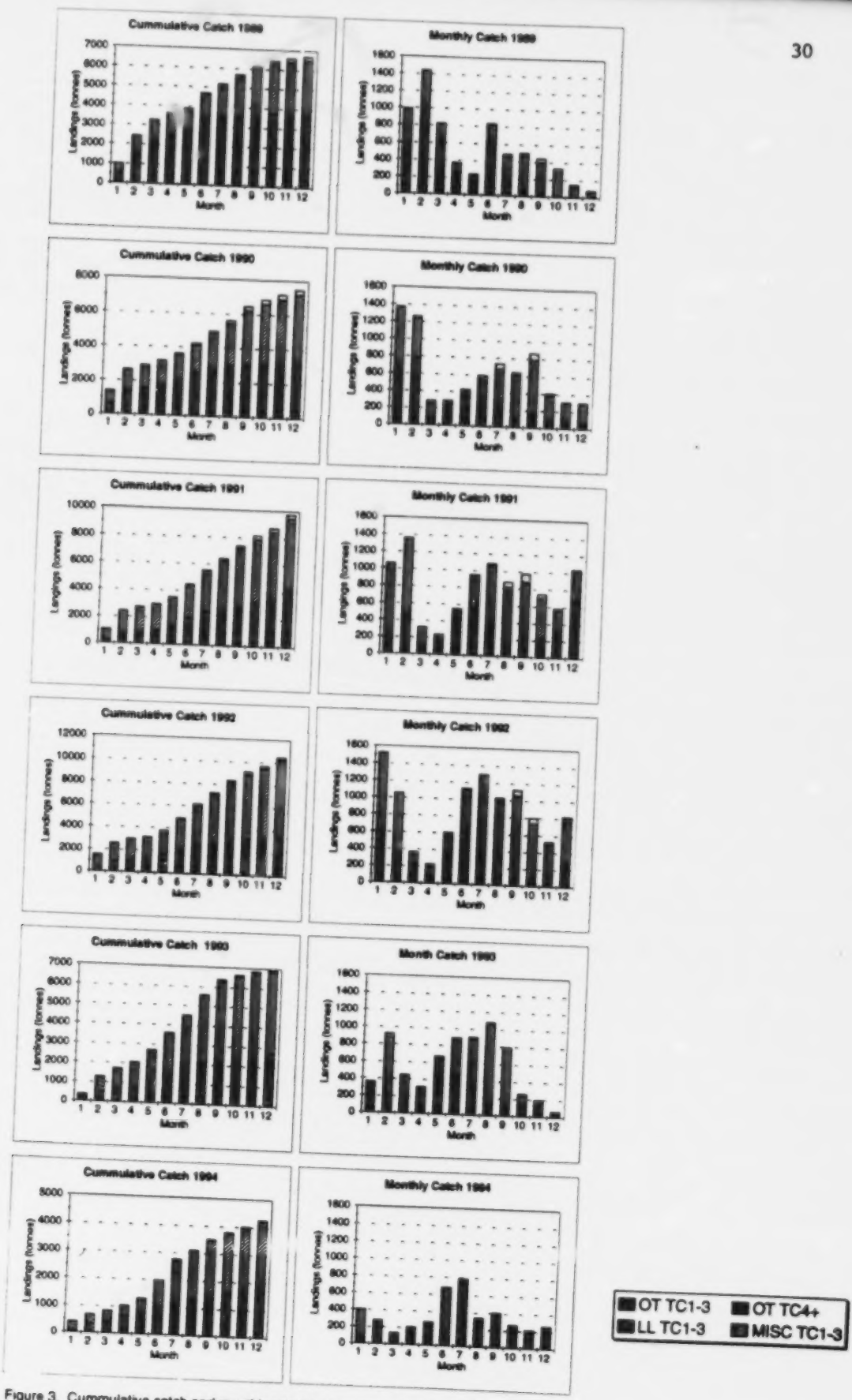


Figure 3. Cummulative catch and monthly catch by gear sector, 4X haddock 1990-1993.

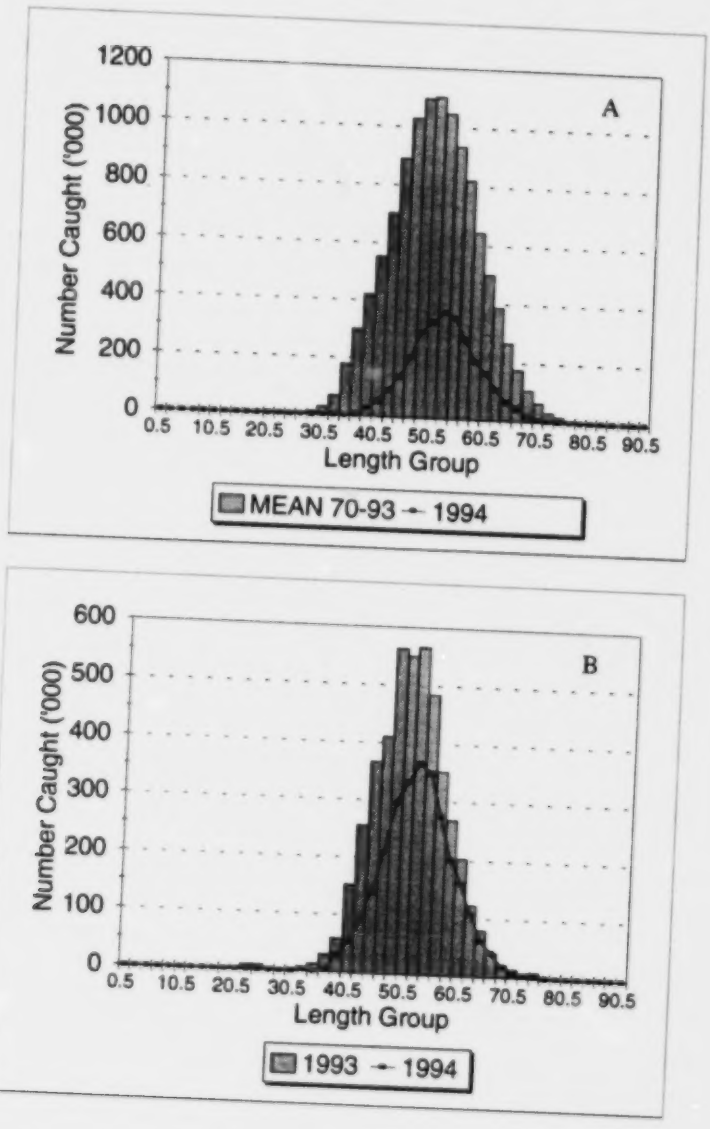


Figure 4. Commercial catch at length for 4X haddock, (a) 1994 catch compared to the 1970-1993 mean, (b) 1994 catch compared to the 1993 catch at length.

tcal7094.wb1

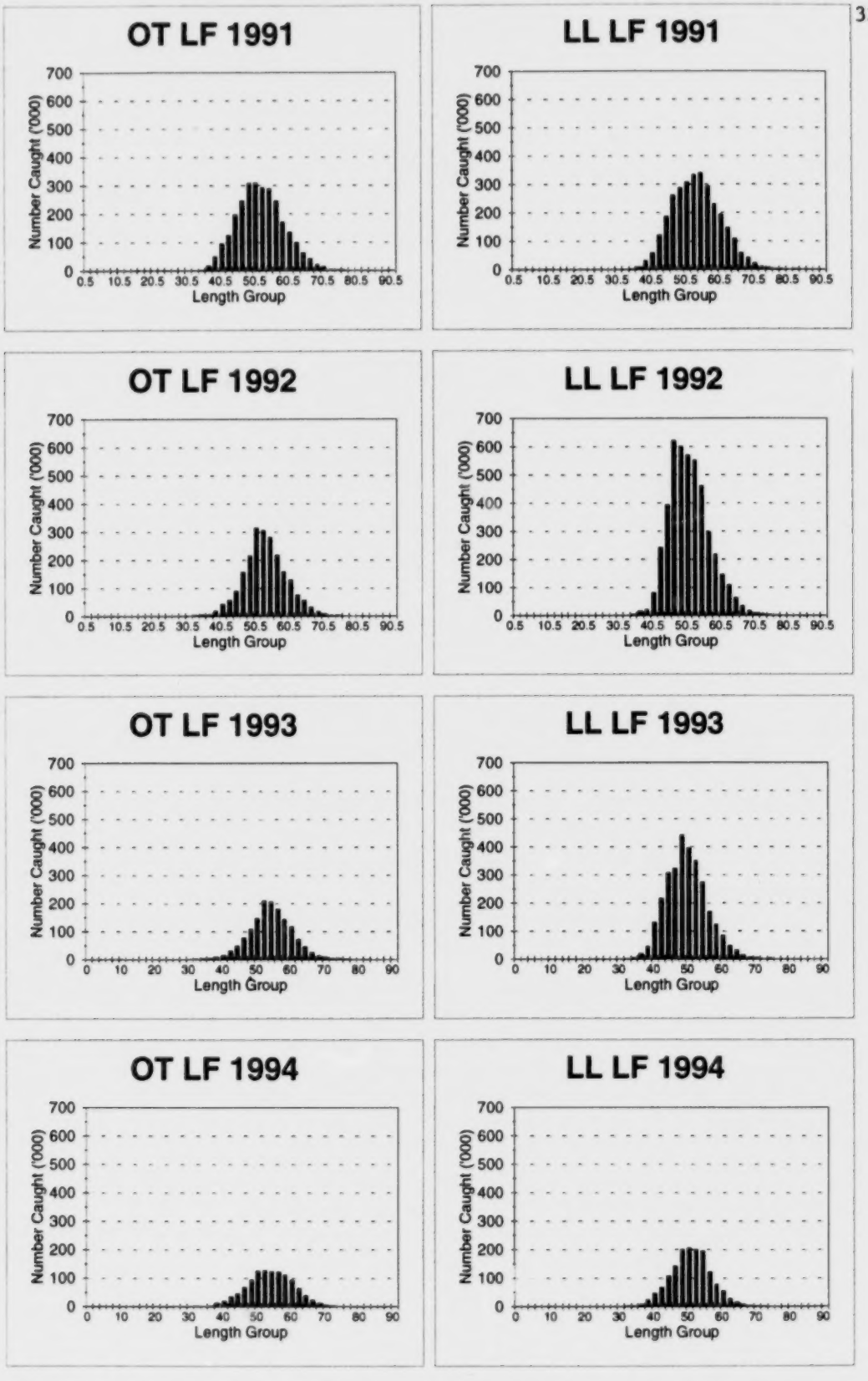


Figure 5. Catch at length (cm) for 4X haddock, 1991-1994, for the otter trawl and longline gear sectors.

ll_gear.wb1

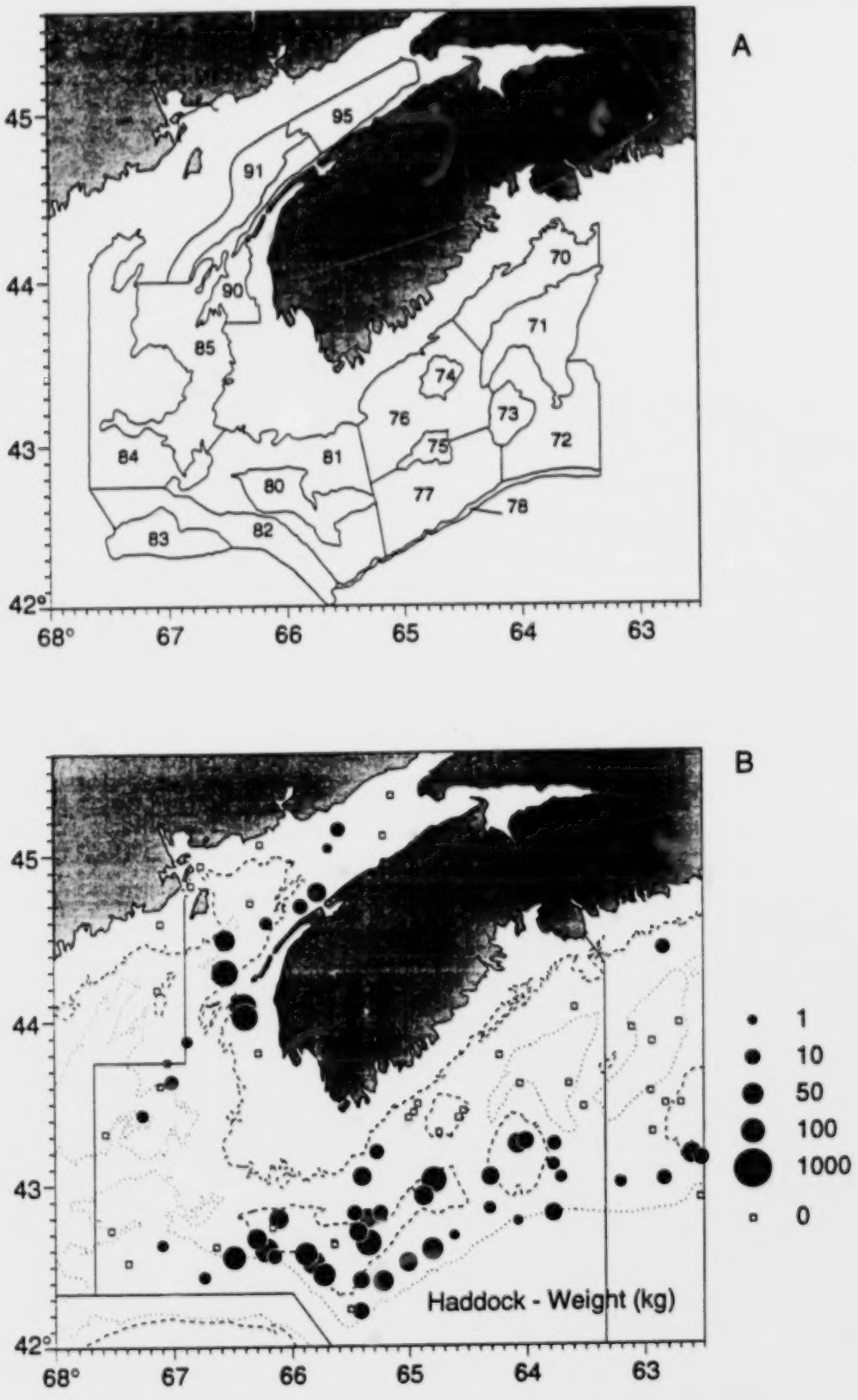


Figure 6. (A) RV survey strata in NAFO Division 4X. (B) Haddock catch and distribution in the 1994 summer RV survey.

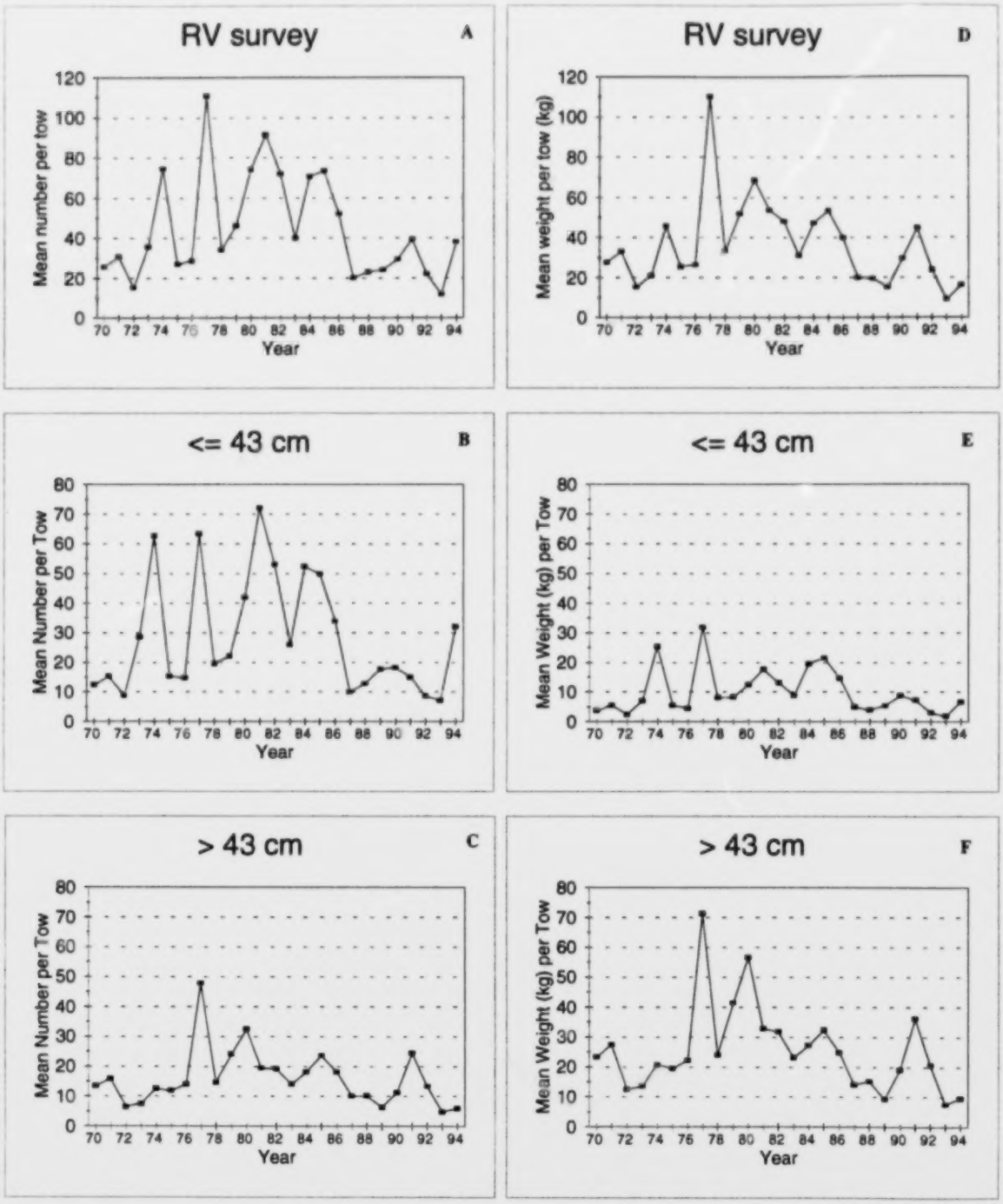


Figure 7. Summer RV survey, mean catch rate of haddock from 4X during 1970-1995 for (a) all lengths combined (nos./tow), (b) lengths <=43 (nos./tow), (c) lengths >43cm (nos./tow), (d) all lengths combined (wt/tow), (e) lengths <=43cm (wt/tow) and (f) lengths >43cm (wt/tow).

nptplot.wb1

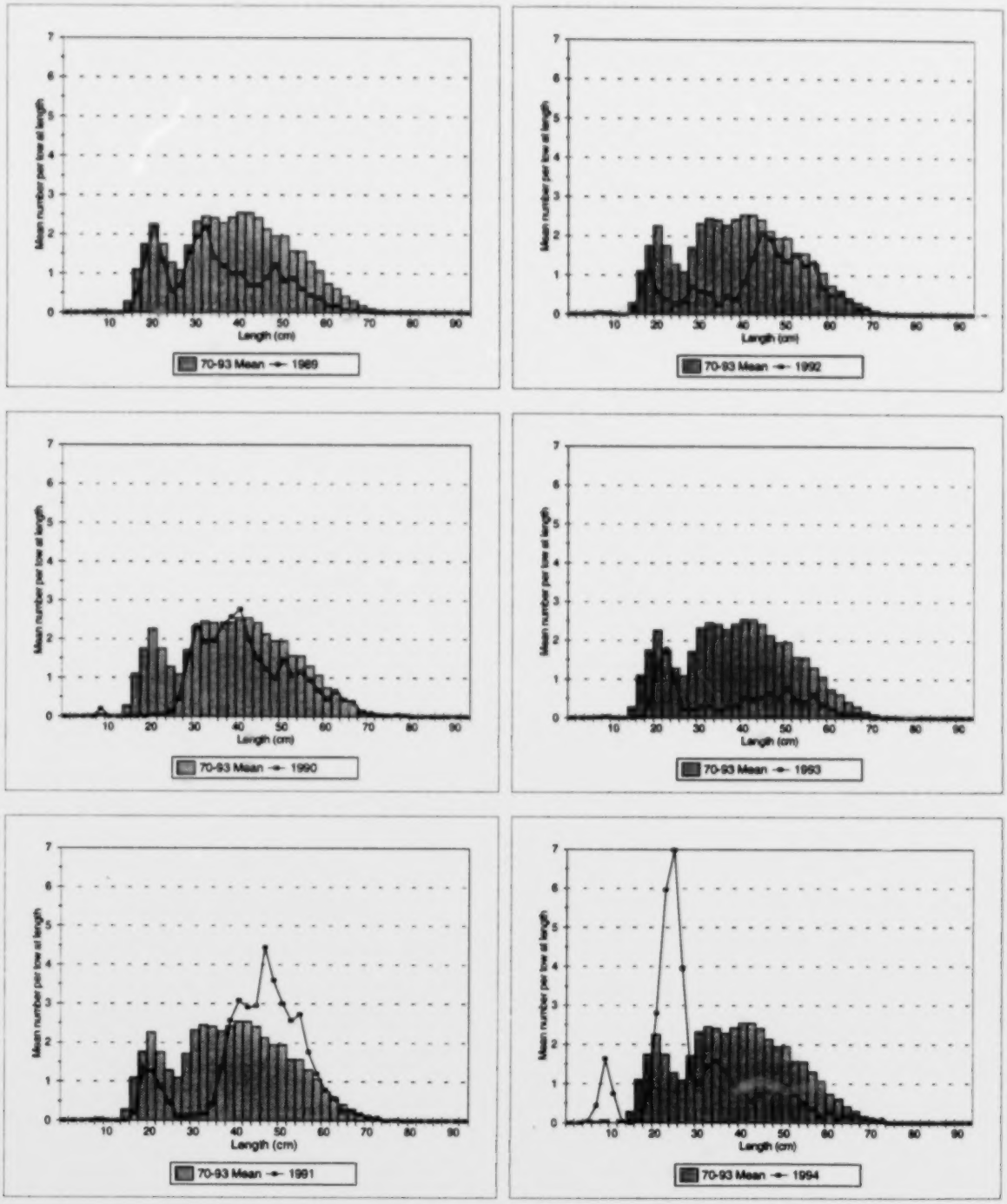


Figure 8. Summer RV survey mean number per tow at length for 4X haddock, 1989 - 1994, compared with the 1970-1993 mean.

rvsplot.wb1

Figure 9. 4X haddock summer RV survey stratified numbers by stratum grouping

strapwin.wb1

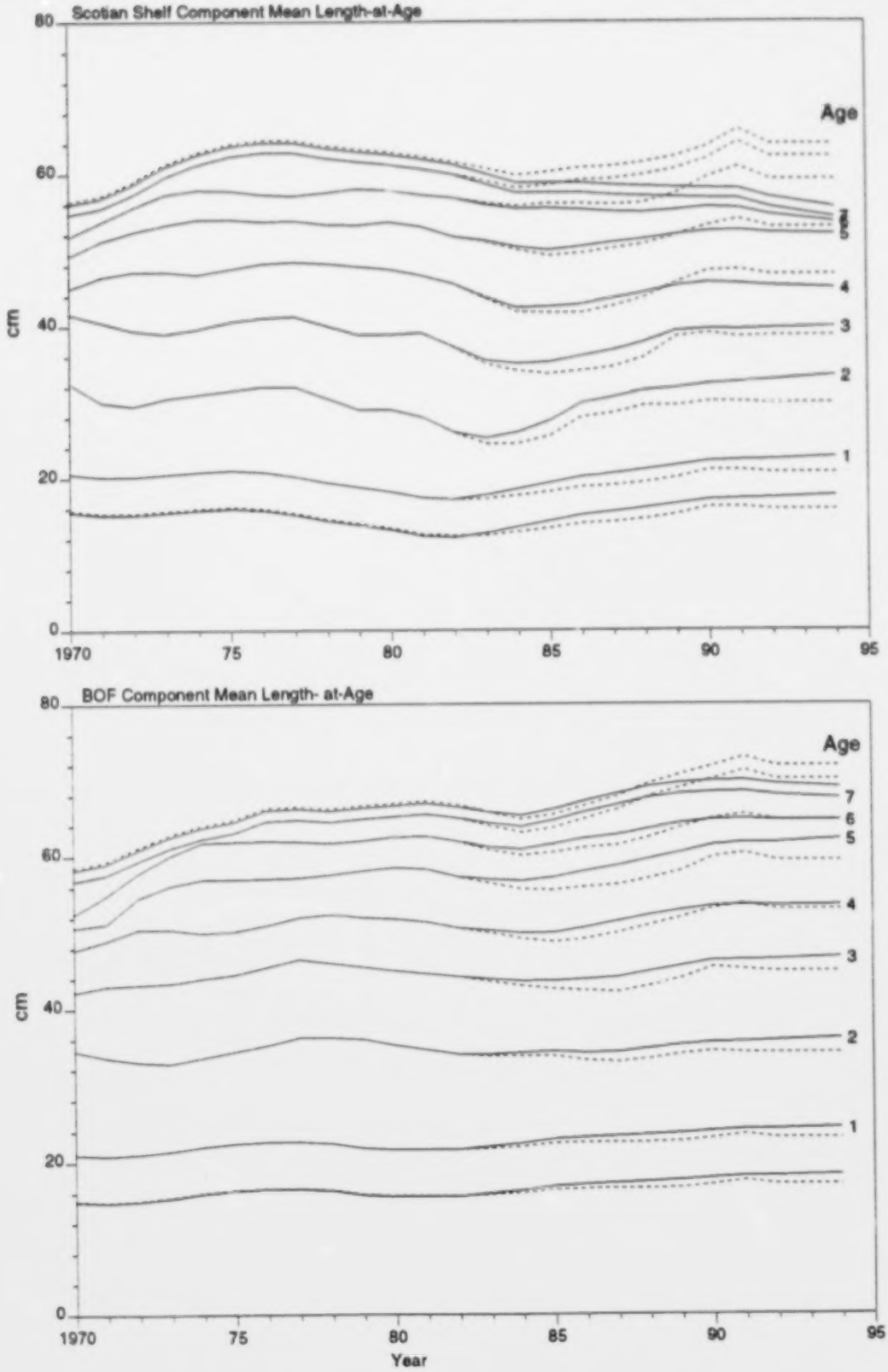


Figure 10. Mean lengths-at-age calculated from 94 pro-rated model (see text for explanation) plotted as solid lines (dashed lines are from original ageing data - 1992-94 are average of 1989-91).

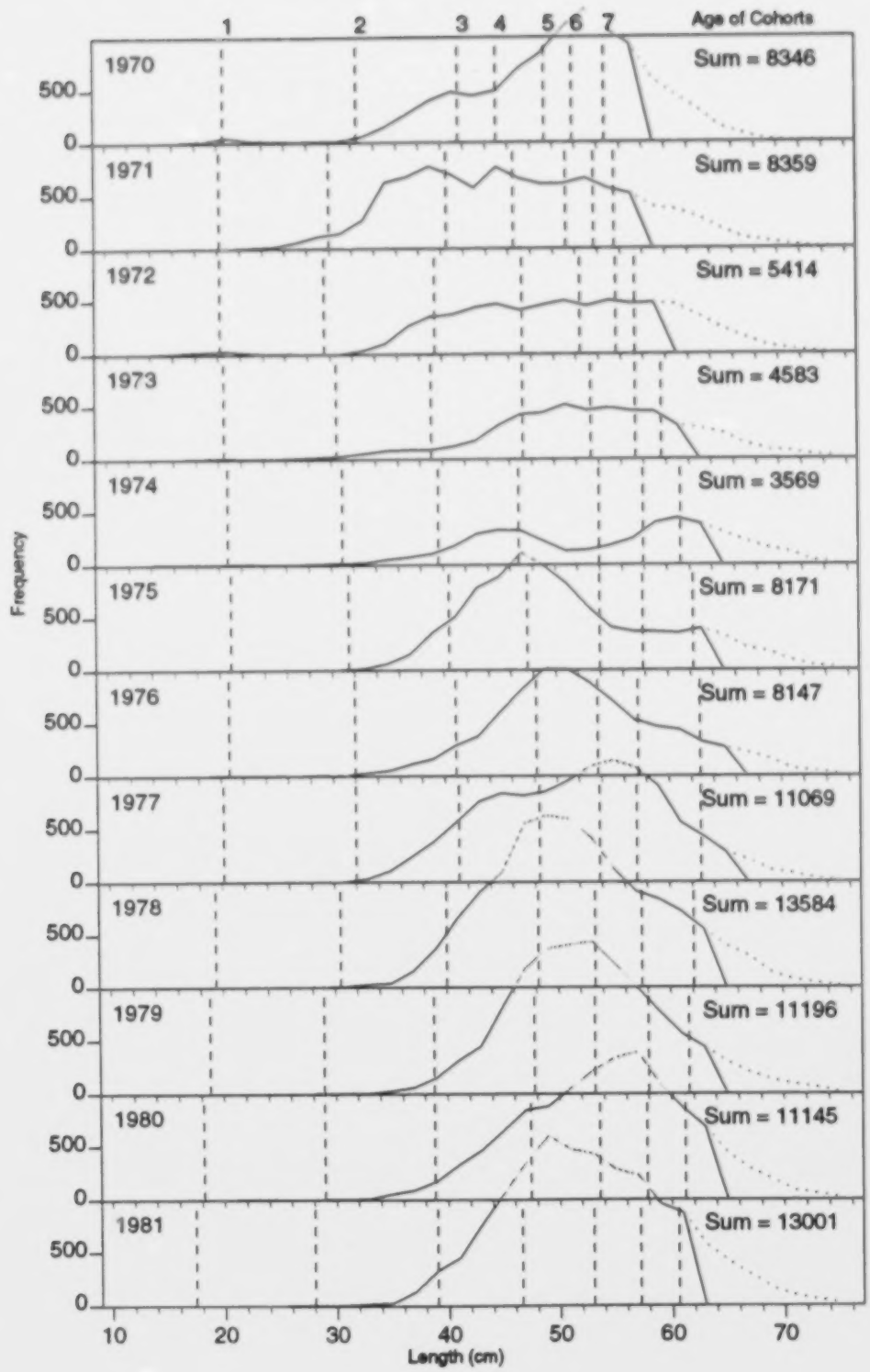


Figure 11a. Scotian Shelf component commercial catch-at-length distribution (solid line) by year (1970-81) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in the analysis.

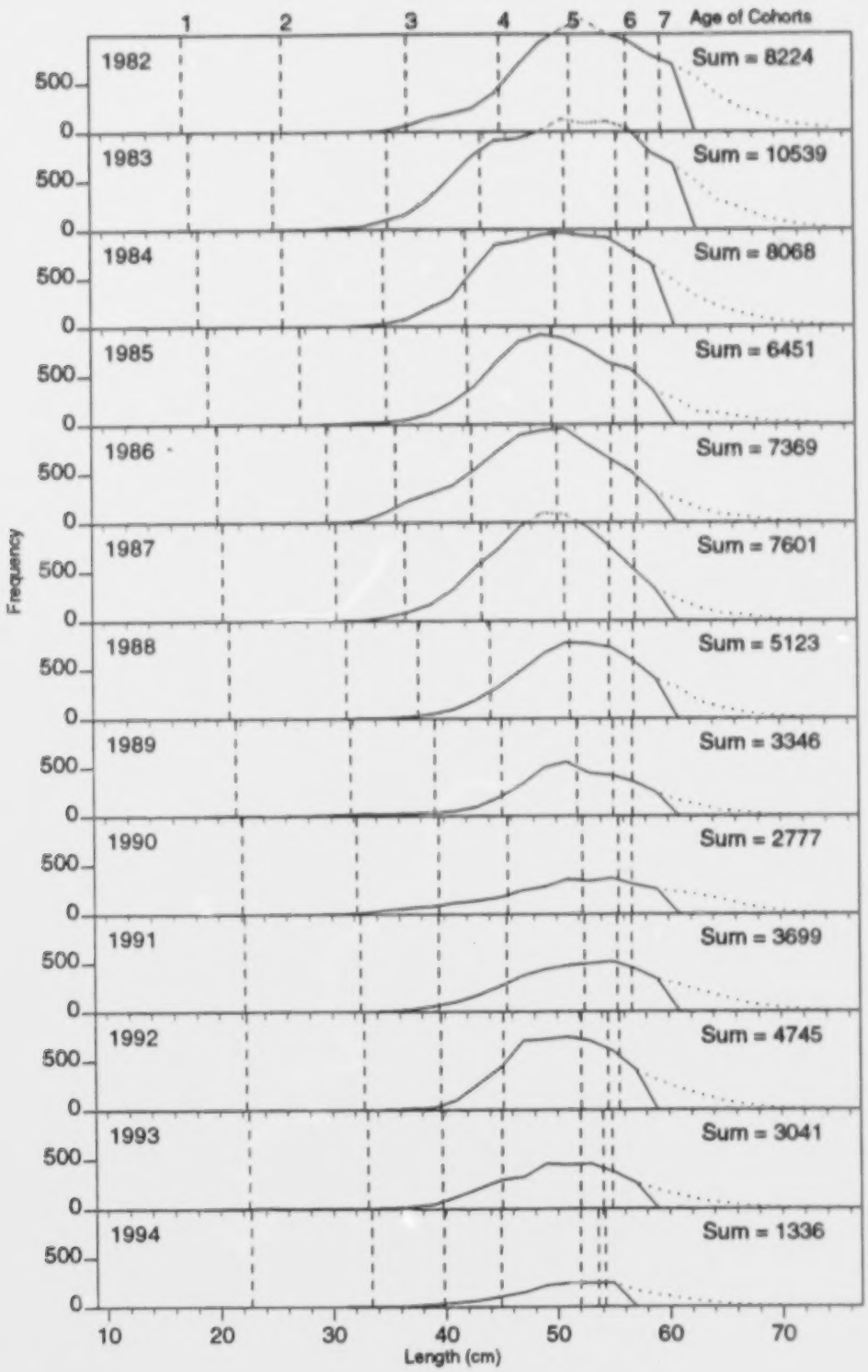


Figure 11b. Scotian Shelf component commercial catch-at-length distribution (solid line) by year (1982-94) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in the analysis.

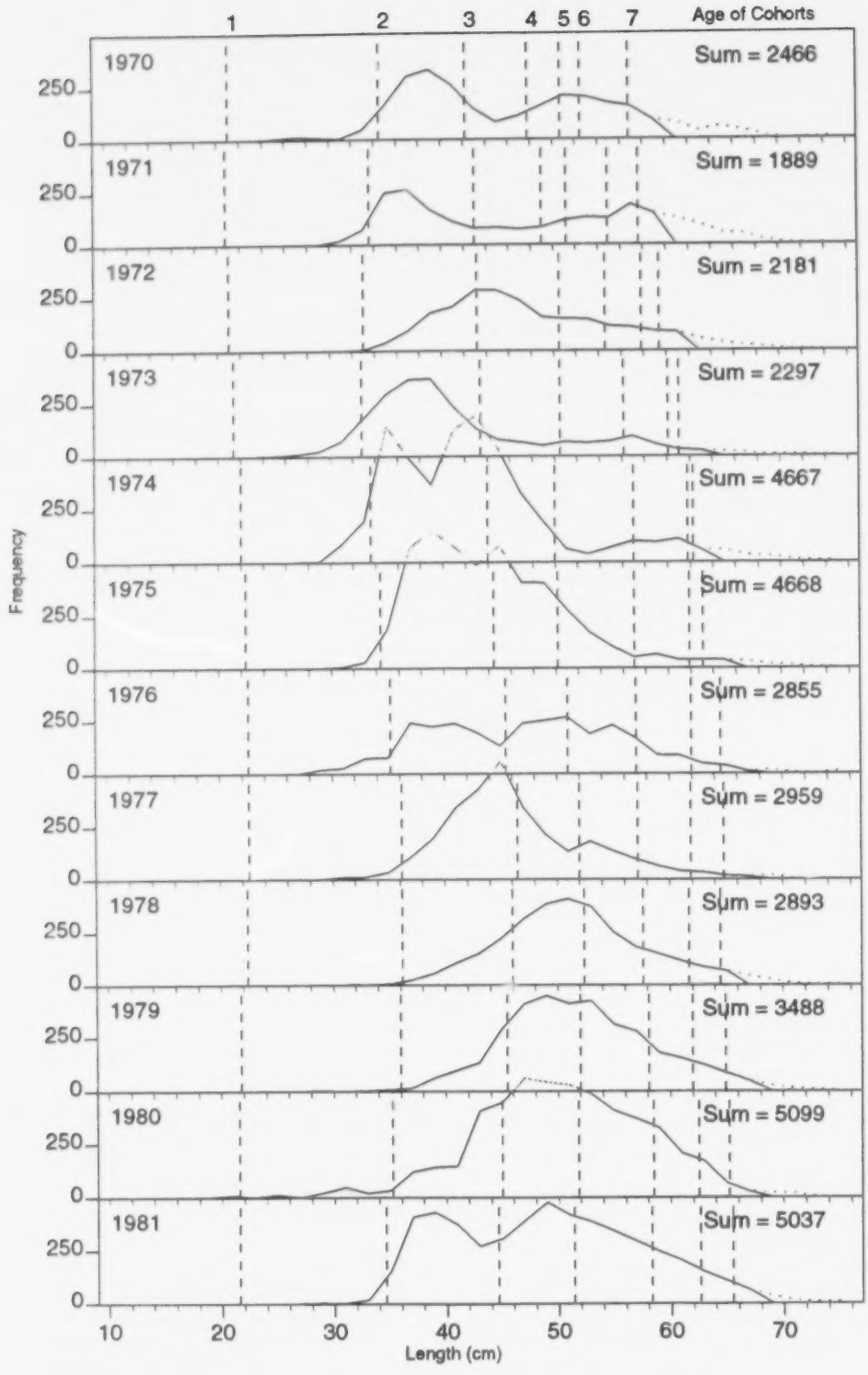


Figure 11c. Bay of Fundy component commercial catch-at-length distribution (solid line) by year (1970-81) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in the analysis.

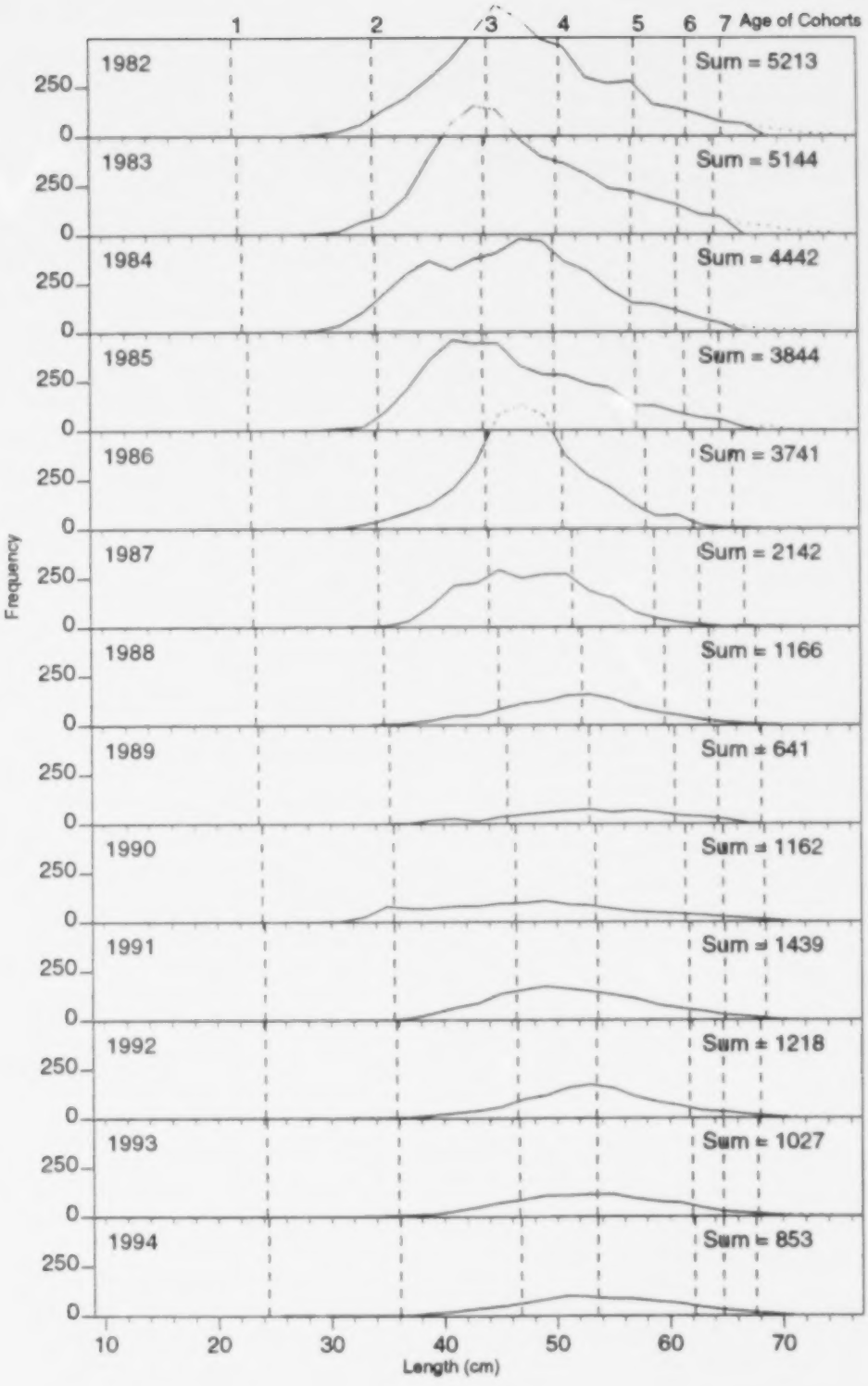


Figure 11d. Bay of Fundy component commercial catch-at-length distribution (solid line) by year (1982-94) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in the analysis.

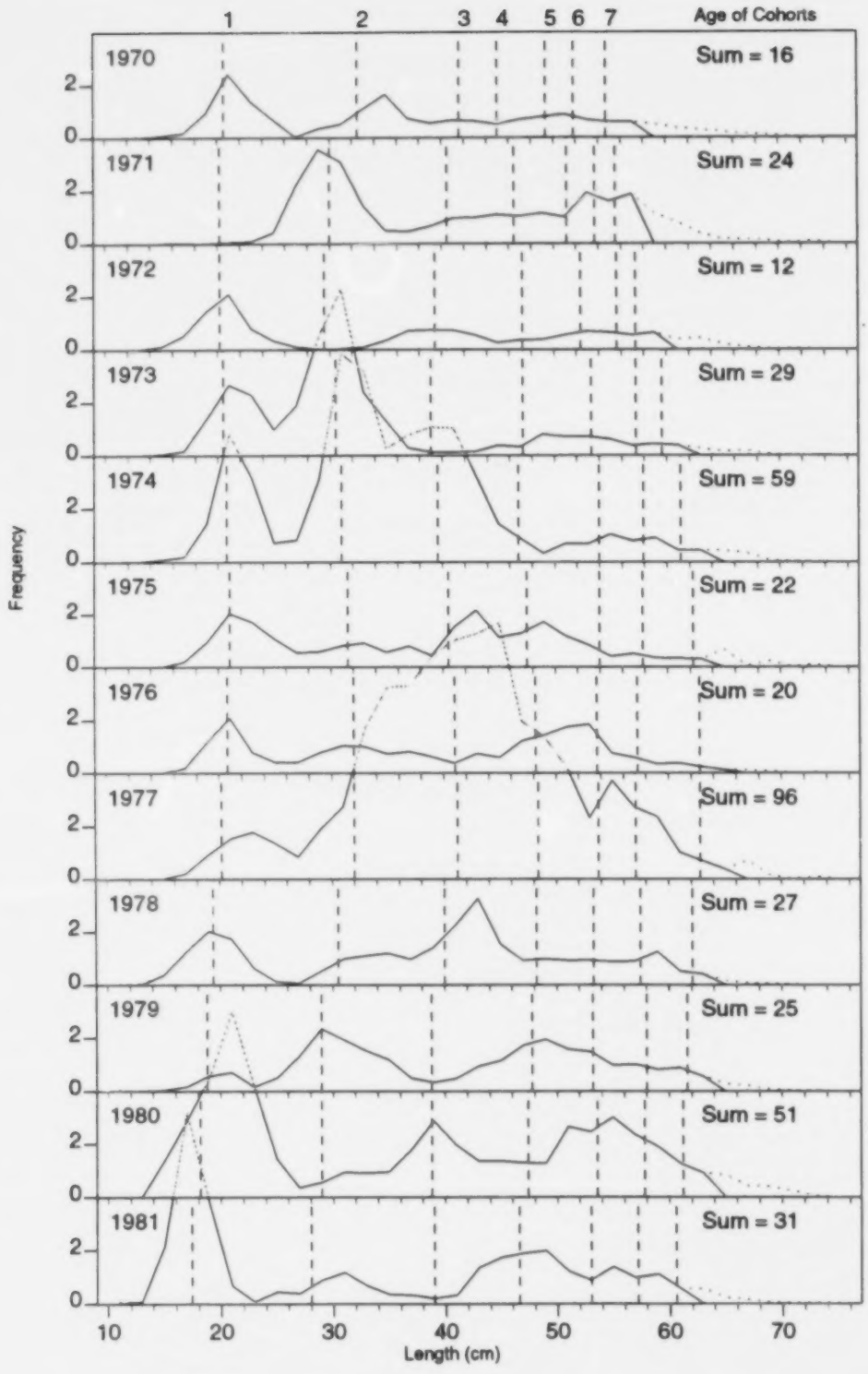


Figure 12a. Scotian Shelf component RV survey numbers-at-length distribution (solid line) by year (1970-81) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in analysis.

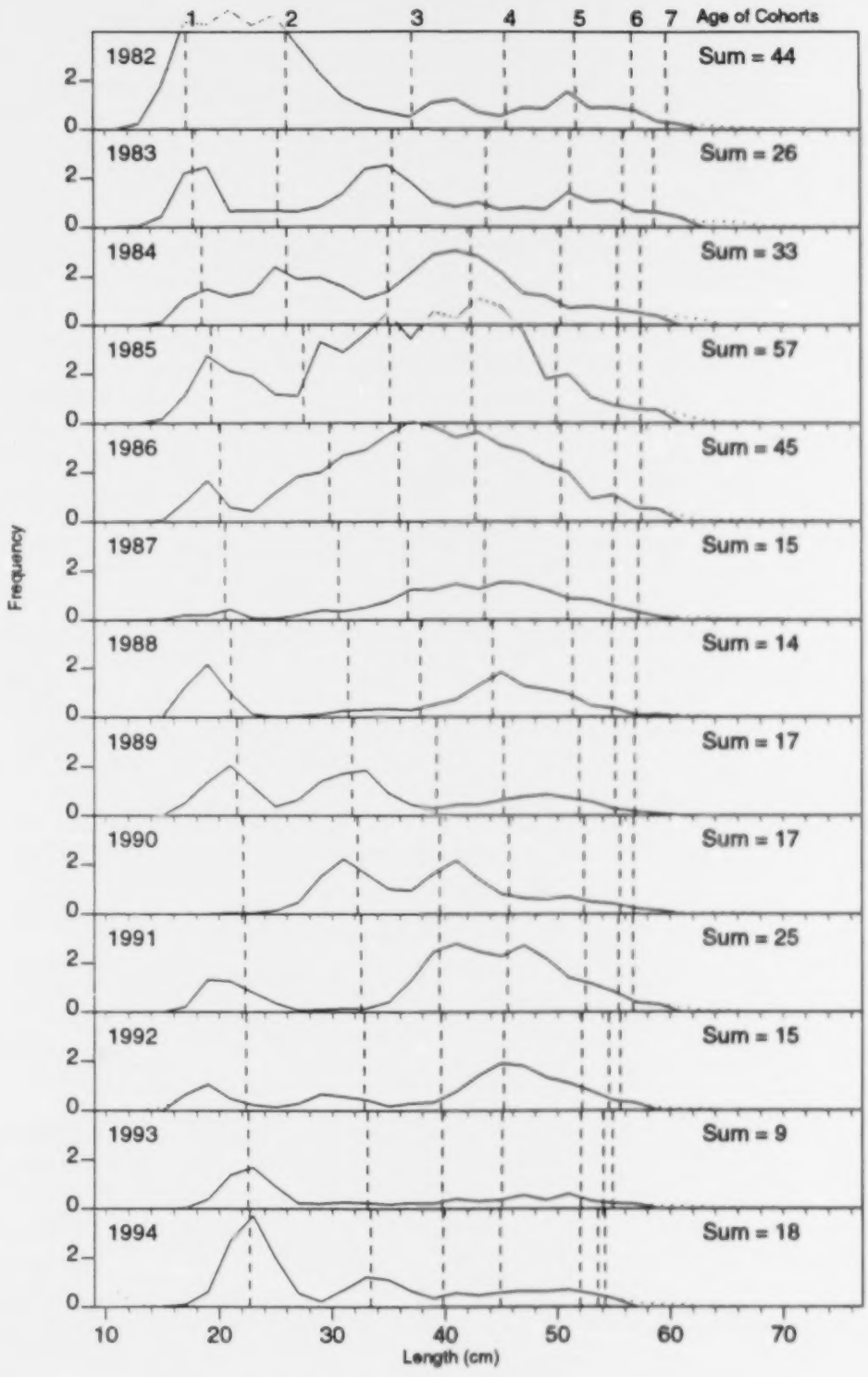


Figure 12b. Scotian Shelf component RV survey numbers-at-length distribution (solid line) by year (1982-94) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in analysis.

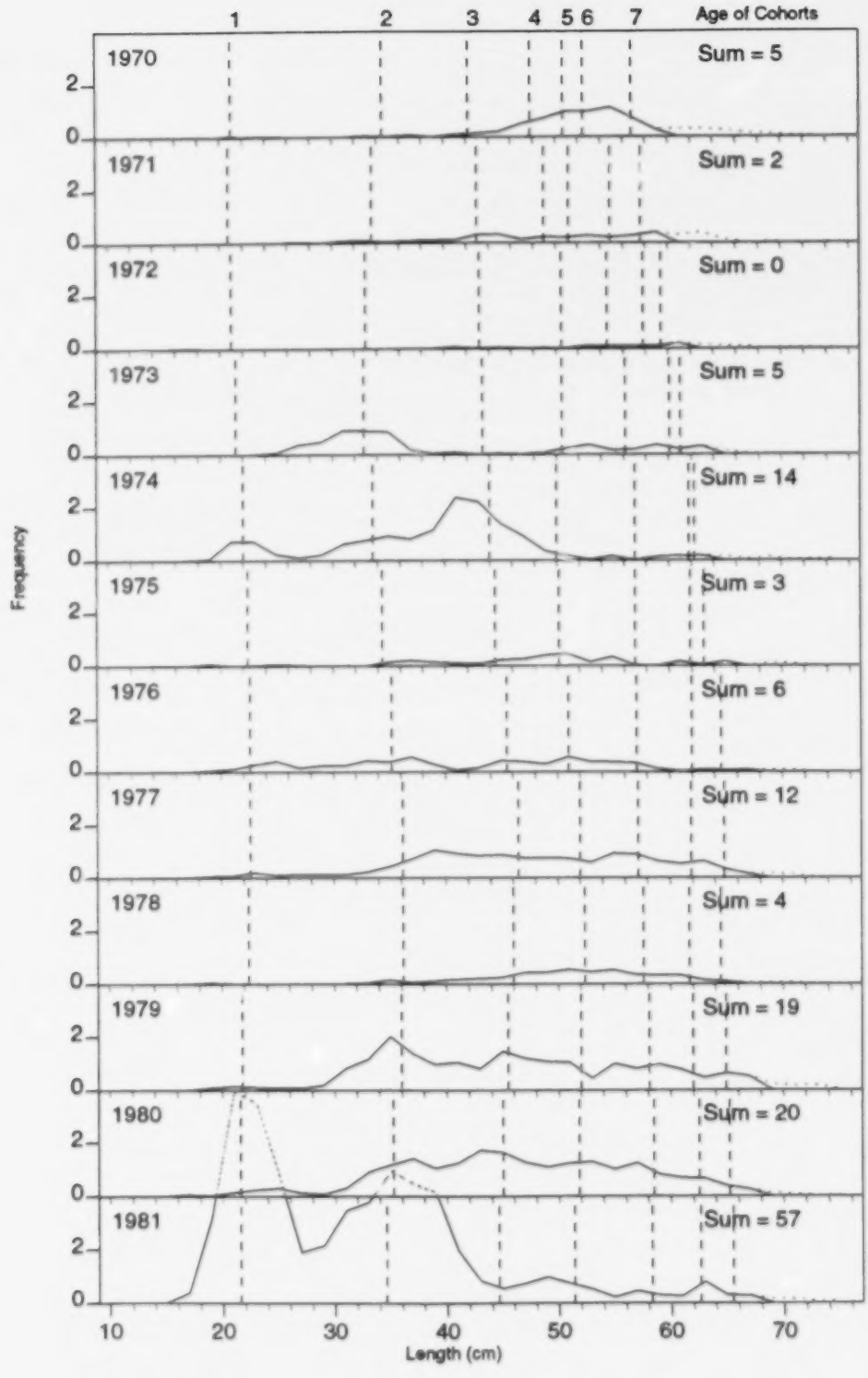


Figure 12c. Bay of Fundy component RV survey numbers-at-length distribution (solid line) by year (1970-81) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in analysis.

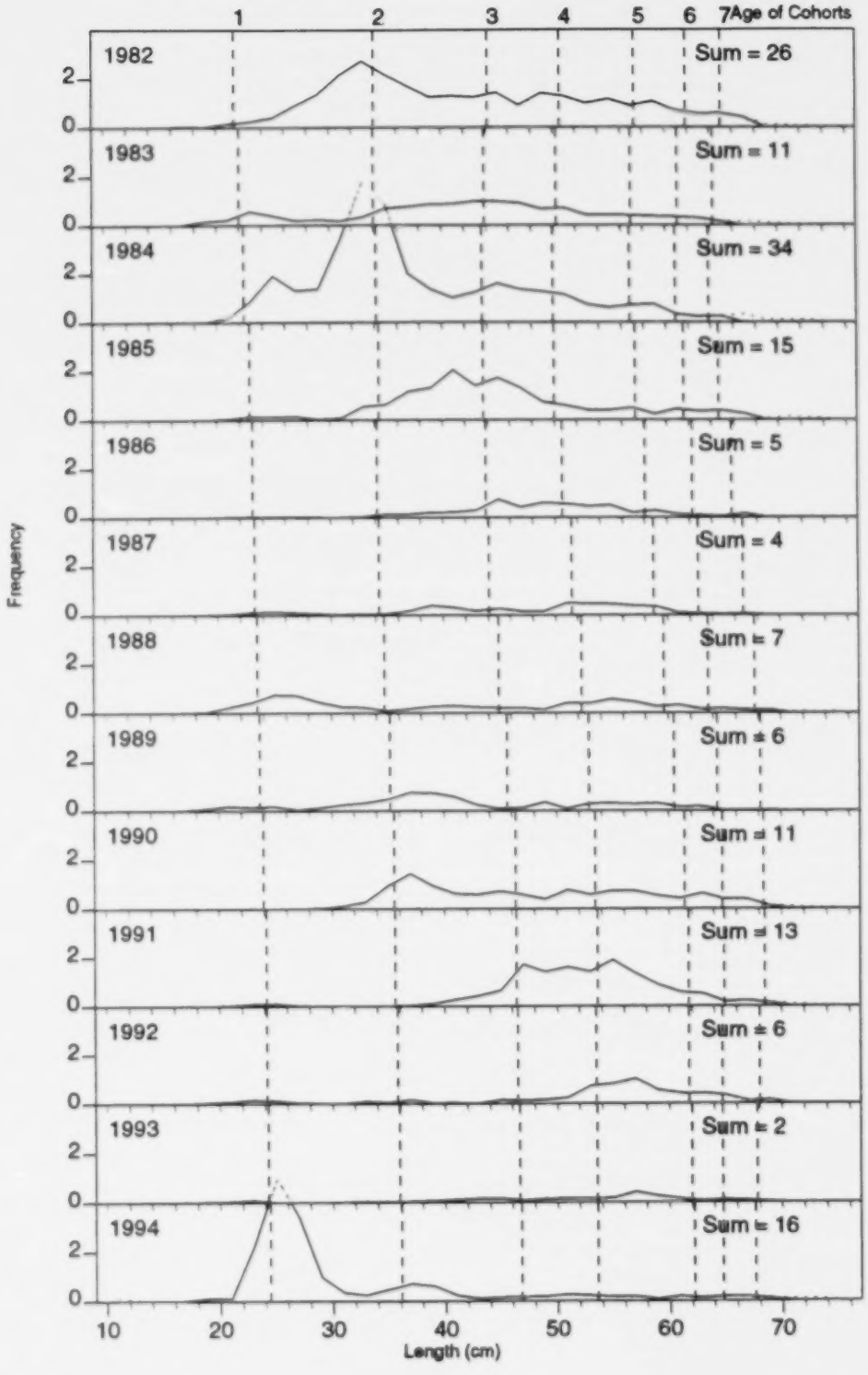
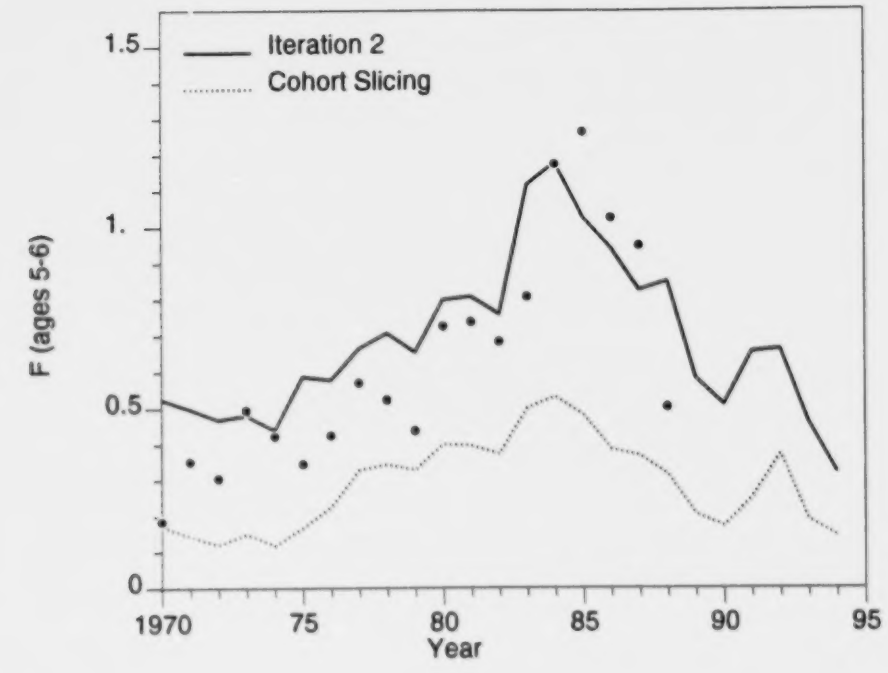


Figure 12d. Bay of Fundy component RV survey numbers-at-length distribution (solid line) by year (1982-94) showing mean length-at-age data (vertical dashed lines) used in cohort slicing. Dotted lines on extreme left and right of distributions represent ages 0 and 8+ that are not included in analysis.



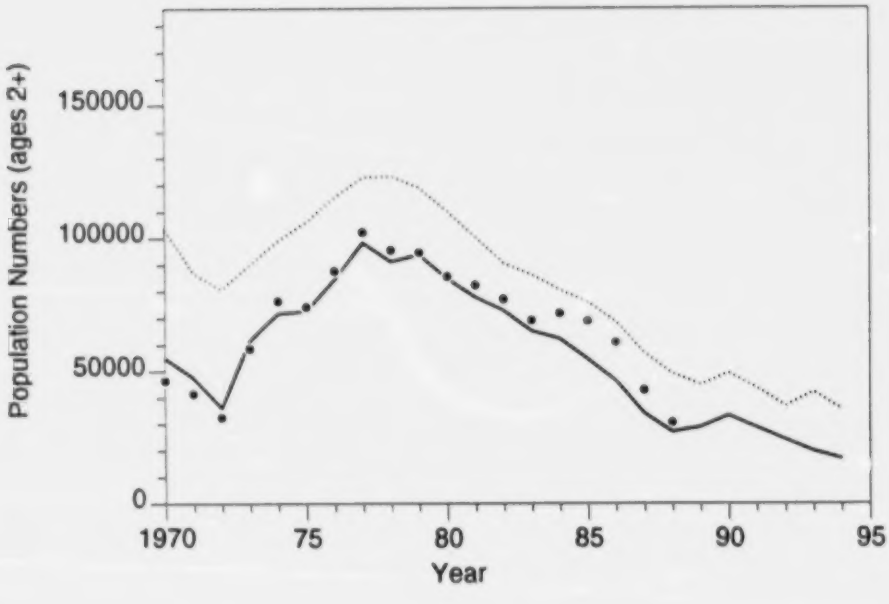


Figure 13. SPA results using mean lengths-at-age calculated from 94 ages prorated model.

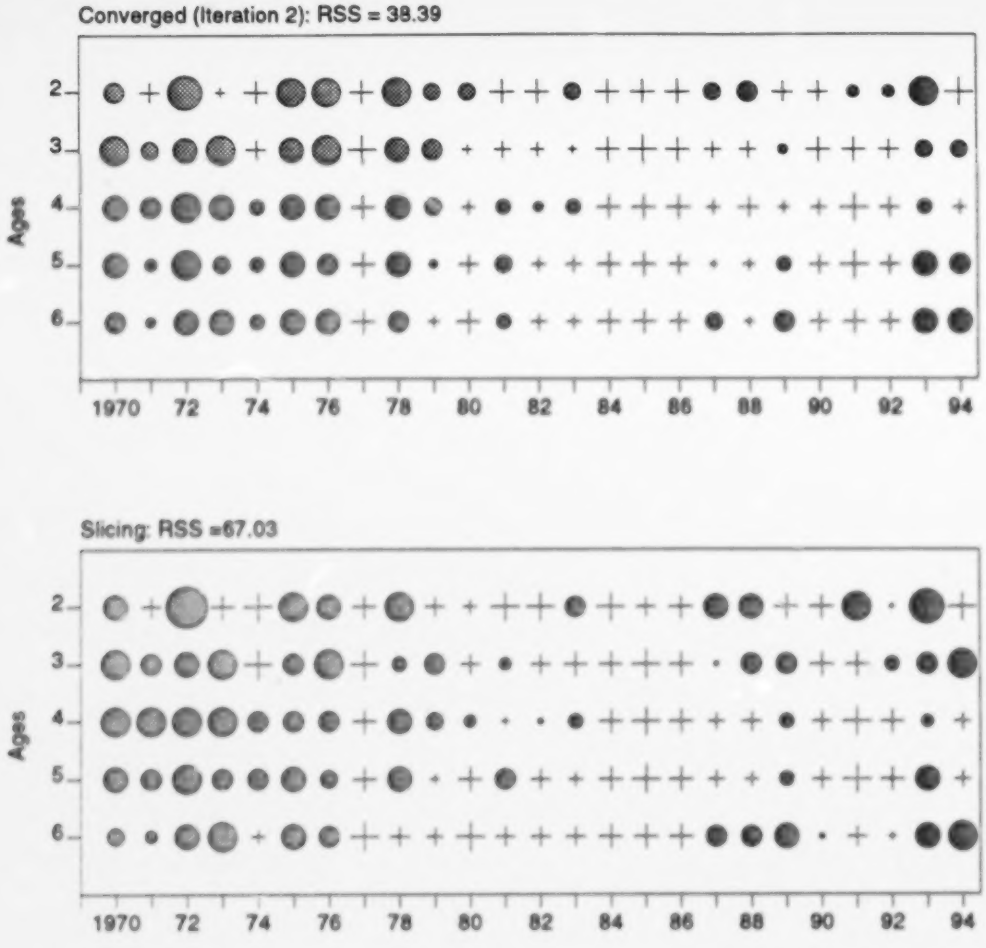


Figure 14. SPA results (residual pattern) using mean lengths-at-age from 94 ages prorated model, from cohort slicing (lower) and after one iteration of SP Key (upper).

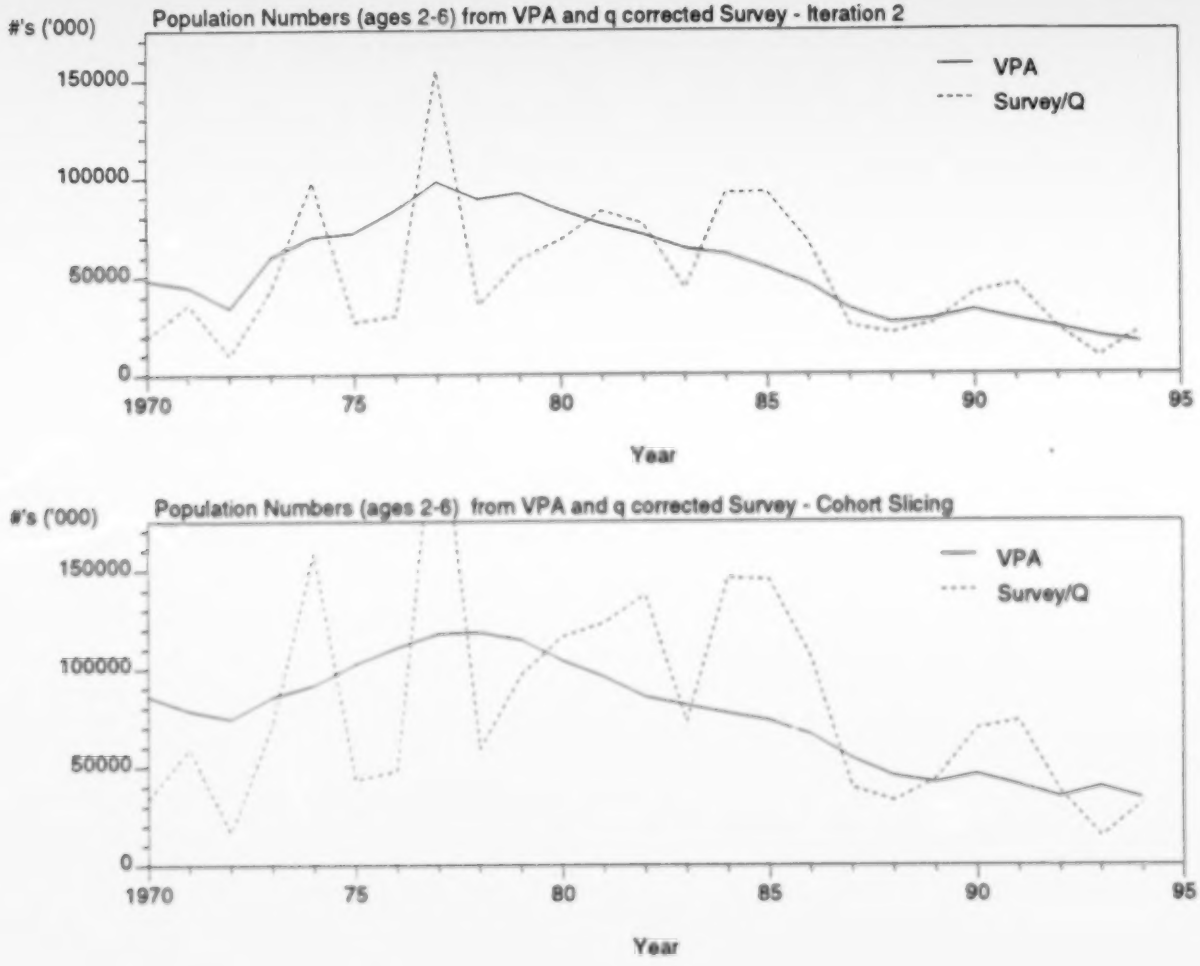


Figure 15. SPA results (comparison of SPA and RV survey) using mean lengths-at-age calculated from 94 ages prorated model, from cohort slicing (lower) and after one iteration of SP Key (upper).

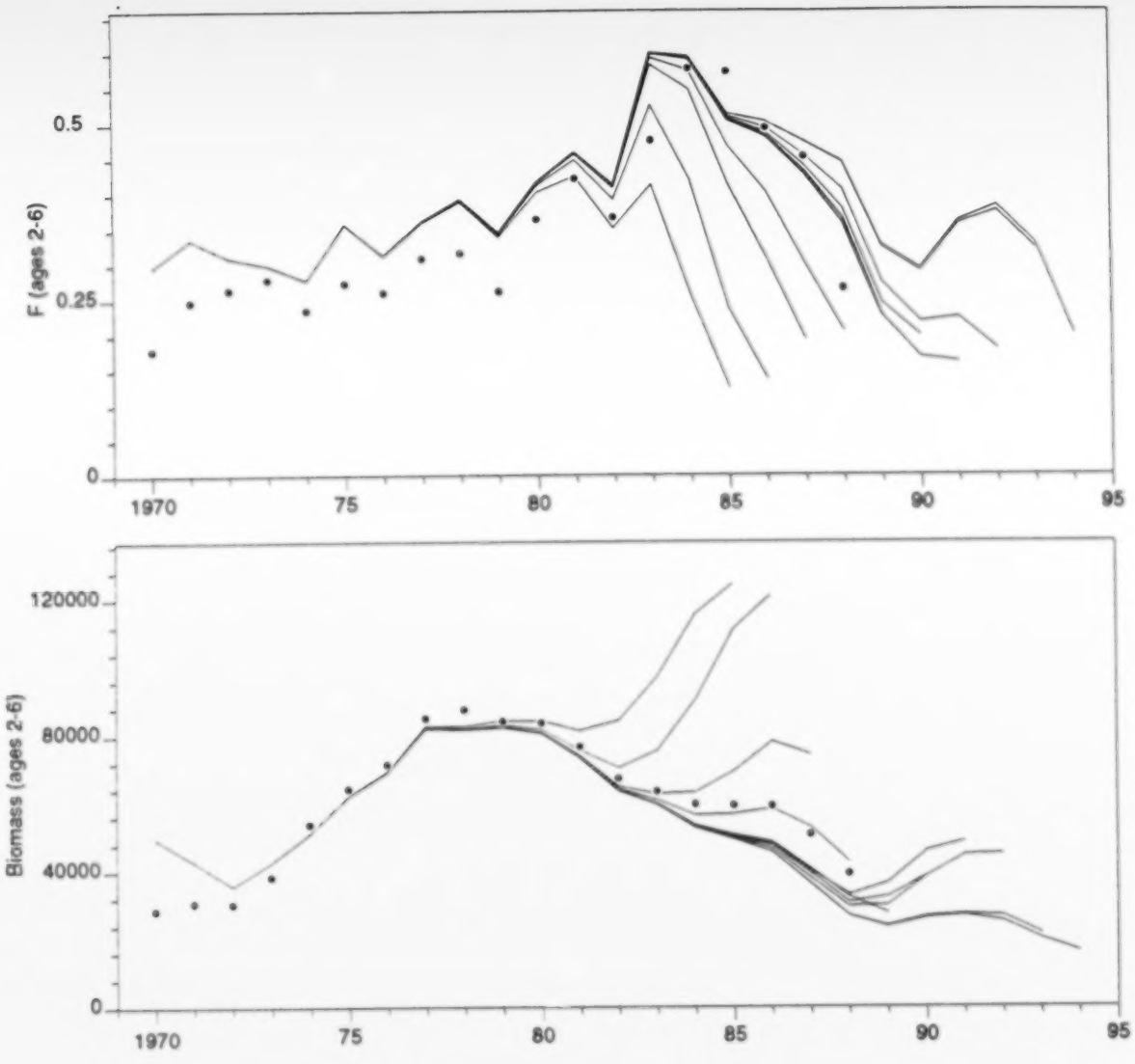


Figure 16. Retrospective analysis of SPA results using mean lengths-at-age calculated from 94 ages prorated model.

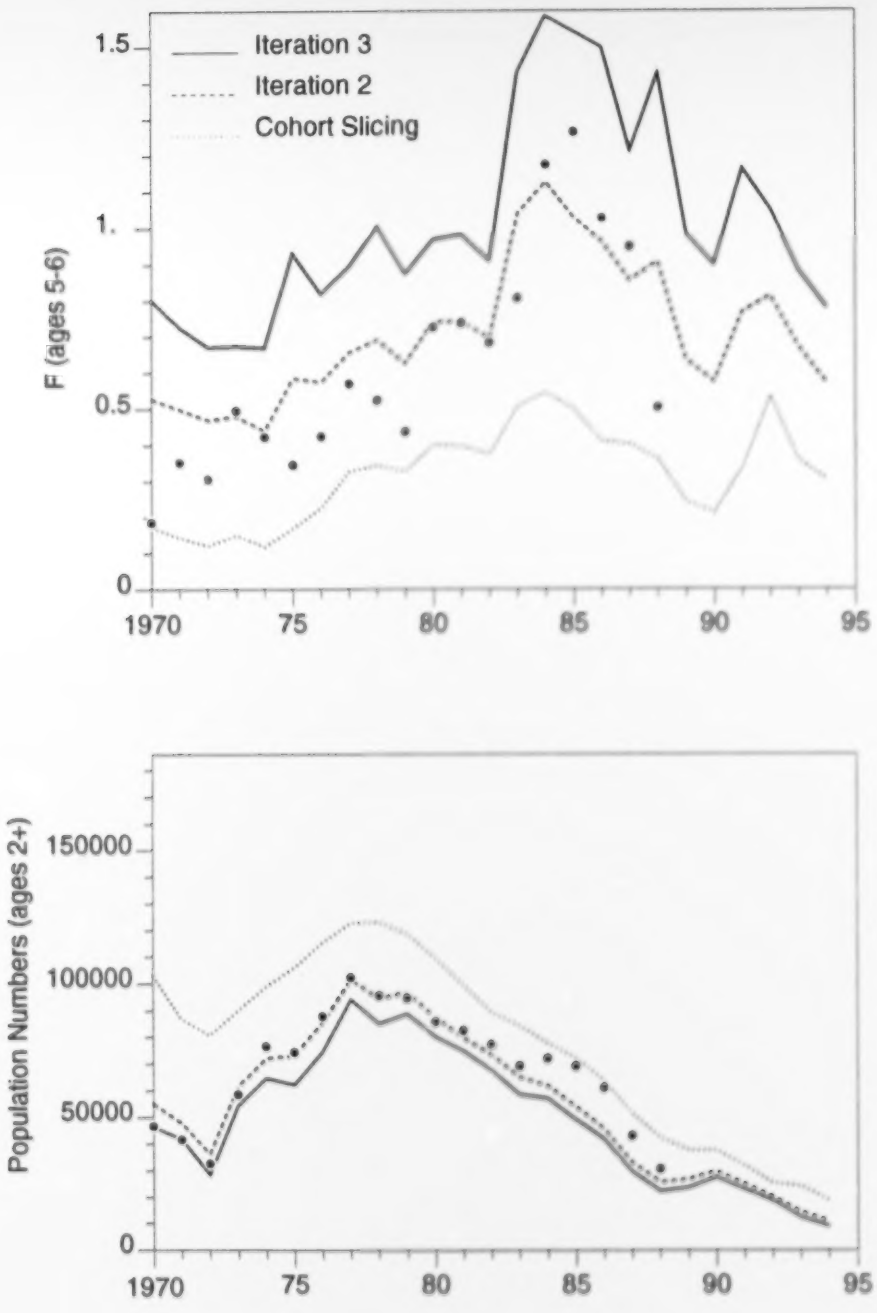


Figure 17. SPA results using mean lengths-at-age calculated from 94 ages prorated model, incorporating 0.55 conversion factor for 1982-94 RV survey data, from cohort slicing (lower) and after iterations of SP Key (middle and upper).

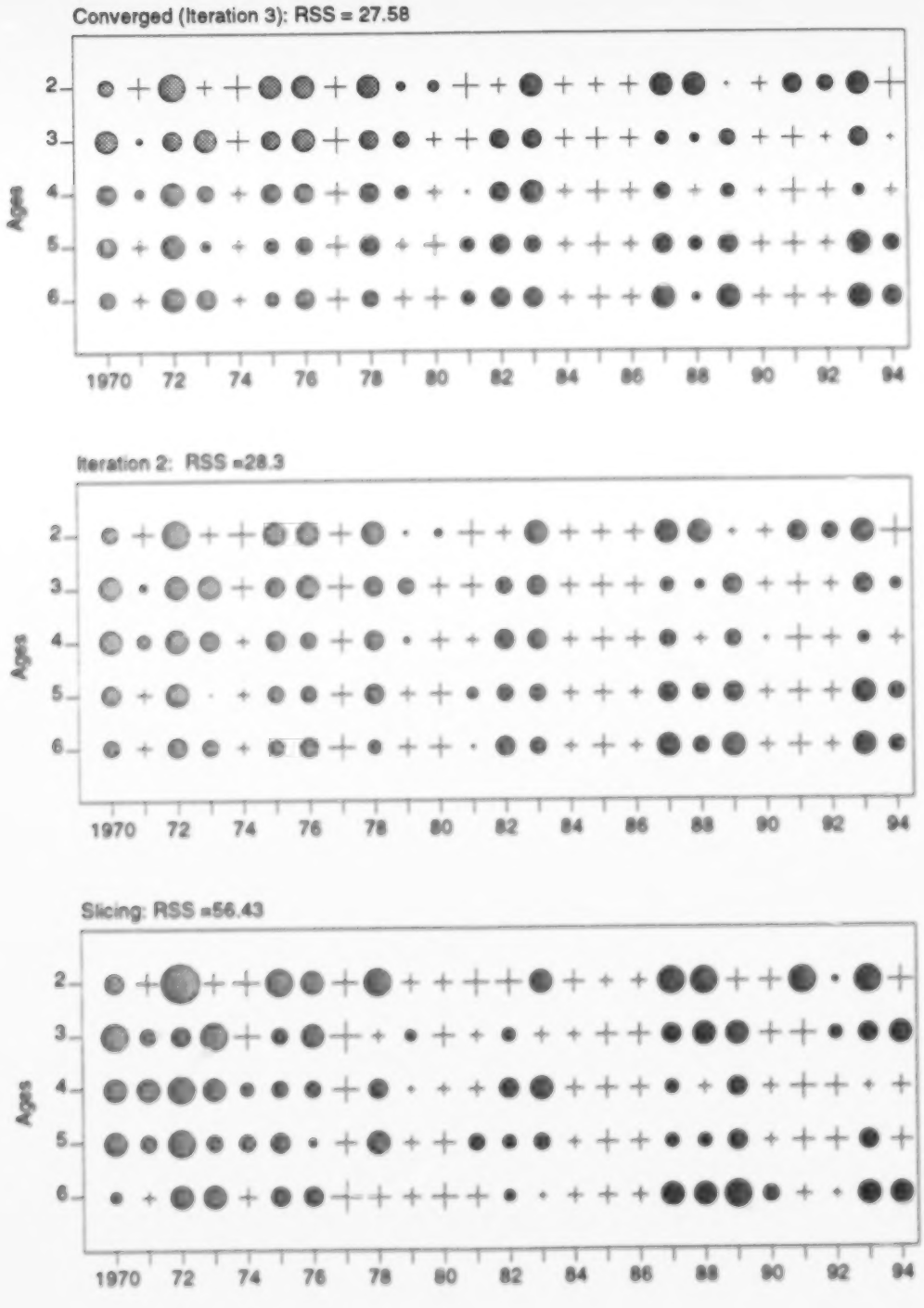
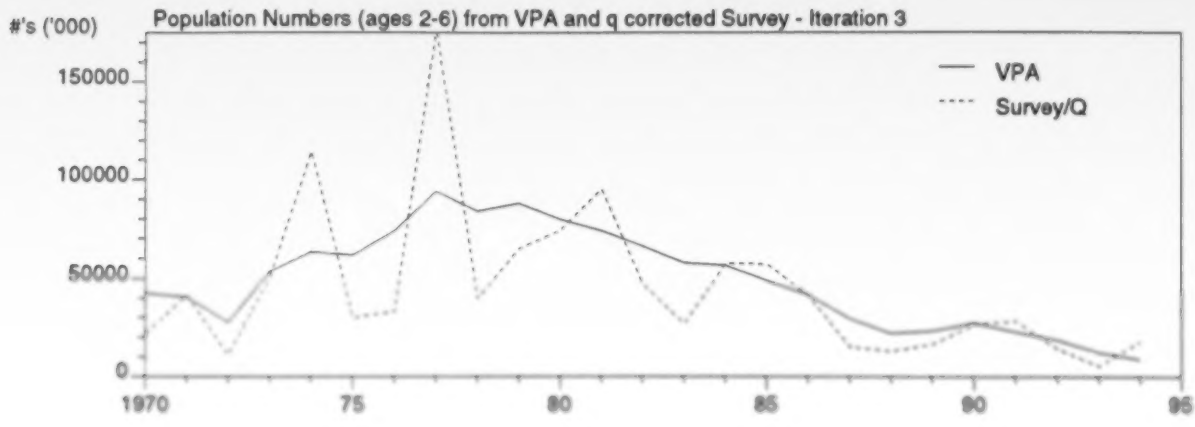
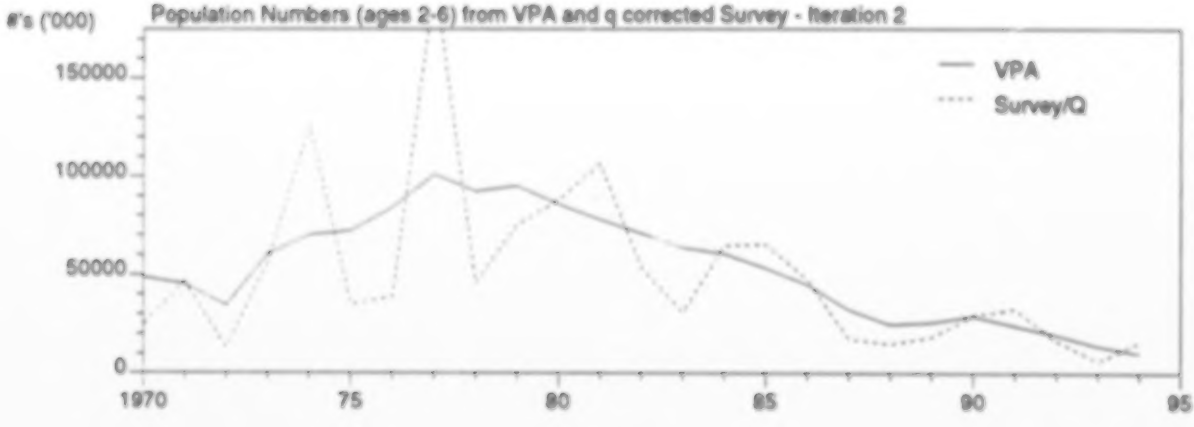


Figure 18. SPA results (residual pattern) using mean lengths-at-age calculated from 94 ages prorated model, incorporating 0.55 conversion factor for 1982-94 RV survey data, from cohort slicing (lower) and after iterations of SP Key (middle and upper).





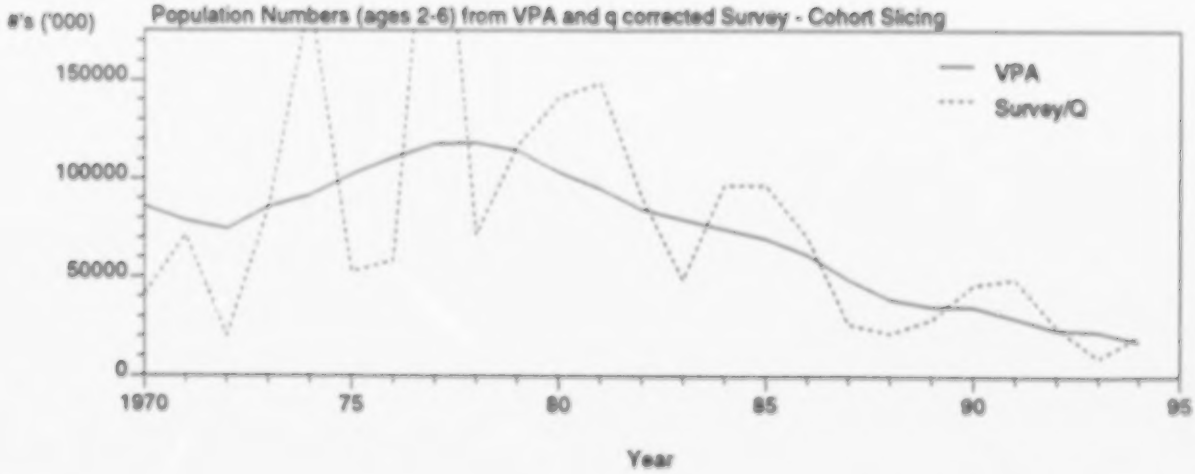


Figure 19. SPA results (comparison of SPA and RV survey) using mean lengths-at-age calculated from 94 ages prorated model, incorporating 0.55 conversion factor for 1982-94 RV survey data, from cohort slicing (lower) and after iterations of SP Key (middle and upper).

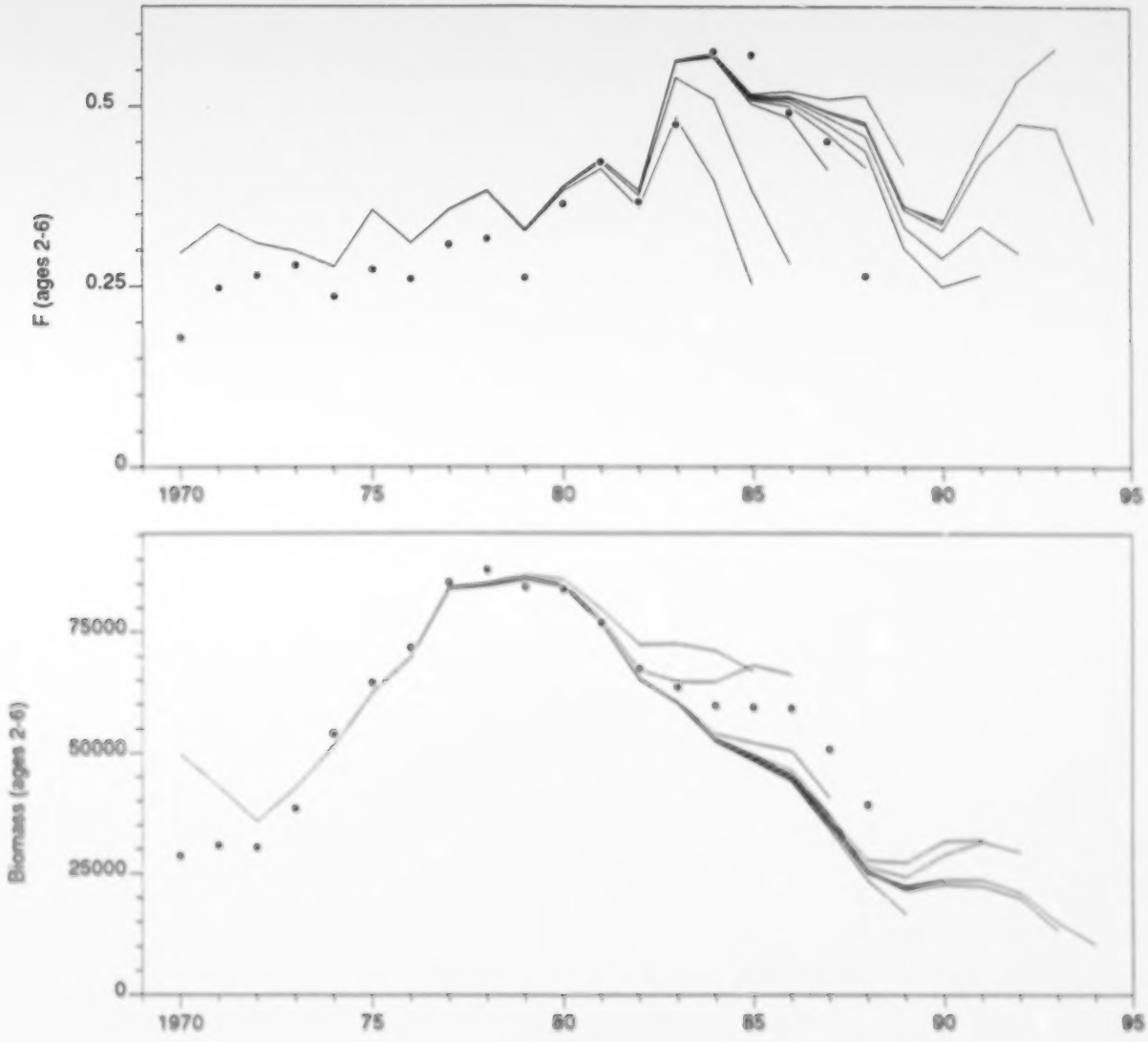


Figure 20. Retrospective analysis of SPA results using mean lengths-at-age calculated from 94 ages prorated model, incorporating 0.55 conversion factor for 1982-94 RV survey data.